S
625.70289
T6ASMRP
2002
1

MONTANA DEPARTMENT OF TRANSPORTATION
TASK ORDER NO. 305
ANTI-SKID MATERIAL RESEARCH PROJECT
BENCH-SCALE COLUMNS AND FIELD STUDY REPORT

STATE PUBLICATIONS COLLECTION

NOV 07 2007

MONTANA STATE LIBRARY
1515 E. 6th AVE.
HELENA, MONTANA 59620

Montana State Library
3 0864 1004 1477 3

MONTANA DEPARTMENT OF TRANSPORTATION
TASK ORDER NO. 305
ANTI-SKID MATERIAL RESEARCH PROJECT
BENCH-SCALE COLUMNS AND FIELD STUDY REPORT

Prepared for:

Montana Department of Transportation
Environmental Services
2701 Prospect Avenue
P.O. Box 201001
Helena, MT 59620-1001

Prepared by:

Maxim Technologies, Inc.
303 Irene Street
P.O. Box 4699
Helena, MT 59604

March 2002

Digitized by the Internet Archive
in 2014

https://archive.org/details/montanadepartmen2002maxi

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. FHWA/MT-02-01/8146	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Montana Department of Transportation Task Order No. 305 Anti-Skid Materials Research Project Bench-Scale Columns and Field Study Report	5. Report Date January 2002 6. Performing Organization Code 9911845.100	
7. Author(s) Maxim Technologies, Inc.	8. Report No.	
9. Performing Organization Name and Address Maxim Technologies, Inc. 303 Irene St. P.O. Box 4699 Helena, MT 59604	10. Work Unit No. Task Order No. 305 11. Contract or Grant No.	
12. Sponsoring Agency Name and Address Research, Development, & Technology Transfer Program Montana Department of Transportation 2701 Prospect Avenue PO Box 201001 Helena MT 59620-1001	13. Type of Report and Period Covered Research: 1999-2001 – Final Report 14. Sponsoring Agency Code 5401	
15. Supplementary Notes Research performed in cooperation with the Montana Department of Transportation.		

16. Abstract

The Montana Department of Transportation (MDT) implemented the Anti-Skid Materials (ASM) Research Project to study various alternatives to the present use and storage of sodium chloride (salt)–amended road sand as the primary anti-skid material for traction enhancement on icy and snow-packed highways. Six anti-freezing agents were evaluated that included Salt, Salt Ban, C-50, M-50, and FreezGard. Evaluation criteria included: ability to prevent stockpile freezing, ability to maintain stockpile workability, and propensity to leach from the stockpiles. The project included laboratory column tests to evaluate leaching, and field tests to evaluate freezing, and workability. In addition, SS-1, an asphalt emulsion, was evaluated in the field for its effectiveness as a stockpile cover material. Findings of the study indicated that sodium chloride based additives have the highest propensity to leach; SS-1 is not an effective cover material; and Salt and Salt Ban were the most effective agents in preventing freezing, and in maintaining workability.

17. Key Words Anti-Skid Ice Ban FreezGard Montana, salt, Cal Ban, C-50, M-50, workability, SS-1		18. Distribution Statement	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 198	22. Price

ACKNOWLEDGMENTS

Maxim Technologies, Inc. and the Montana Department of Transportation would like to express their appreciation to the following for their help in developing and implementing the MDT Anti-Skid Material Research Project.

Ed Fick of DustChem who provided many of the anti-freezing agents and assisted in the construction of experimental stockpiles at MDT Bozeman Pass site, in addition to serving in a valuable advisory capacity throughout the project.

MDT Bozeman Maintenance Division maintenance personnel who constructed experimental stockpiles at MDT Bozeman Pass site.

Doug Moeller, MDT Bozeman Maintenance Division Maintenance Chief, and Maurice Dedyker, the MDT Bozeman Maintenance Division Maintenance Superintendent for making available the resources necessary to conduct the project at their MDT Bozeman Pass Stockpile Site.

John Perry of the Federal Highway Administration for serving as a technical advisor.

Members of the MDT Stockpile Research Committee for their time and effort in overseeing development and implementation of the project:

Craig Abernathy
Doug Moeller
Mike Bousliman
Larry Bullock
Maurice Dedyker
Kate Fry
Steven Mattheis
Teresa McNearney
Quentin Miller
Quinn Ness
John Perry
Stan Sternberg
Dan Williams

PREFACE

DISCLAIMER

The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the Montana Department of Transportation or the Federal Highway Administration

ALTERNATE FORMAT STATEMENT

MDT attempts to provide reasonable accommodations for any known disability that may interfere with a person participating in any service, program or activity of the department. Alternative accessible formats of this document will be provided upon request. For further information, call (406) 444-7693 or TTY (406) 444-7696.

NOTICE

The authors, the State of Montana, and the Federal Highway Administration do not endorse products or manufacturers. Trade and manufacturers names appear herein solely because they are considered essential to the object of the report.

EXECUTIVE SUMMARY

In the fall of 1999, the Montana Department of Transportation (MDT) implemented a research project to study various alternatives to the present use and storage of sodium chloride-amended road sand as the primary anti-skid material for traction enhancement on icy and snow-packed highways. Maxim Technologies, Inc.® (Maxim) was retained by MDT to provide assistance and technical oversight for this research project.

Known as the Anti-Skid Material (ASM) Research Project, the study was intended to identify feasible alternatives to the use of sodium chloride as an anti-freezing agent to prevent sand stockpiles from freezing during winter months, and evaluate the feasibility of covering amended sand stockpiles with an asphalt cover. For the evaluation of alternate anti-freezing agents, three primary criteria were identified:

- Propensity of various anti-freezing agents to leach from sand stockpiles as a result of precipitation.
- Ability of various anti-freezing agents to maintain stockpile "workability" by resisting freezing at the outer surface (e.g., developing frost rind).
- Ability of various anti-freezing agents to maintain "workability" as a result of resistance to freezing effects within stockpile interiors under sub-zero (Fahrenheit) weather conditions.

In addition, Slow Set 1 (SS-1), an asphalt emulsion, was evaluated for its effectiveness as a stockpile cover material. The SS-1 study attempted to evaluate ability to minimize leaching as a result of precipitation, and ability to maintain stockpile workability.

The project was divided into two components:

- Laboratory column leach tests conducted at Maxim's Helena, Montana office to evaluate leaching.
- Field tests at a MDT stockpile site located on Interstate Highway I-90 approximately 13 miles east of Bozeman, Montana on top of Bozeman Pass. Field tests attempted to evaluate stockpile workability, and the effectiveness of SS-1 as a cover material.

Six different anti-freezing agents were used in the study and were mixed with road sand as follows:

- *Salt*, industrial grade, crystalline sodium chloride, mixed with road sand at a ratio of 100 lbs per ton of sand (50.0 kg per metric ton);
- *Salt Ban*, salt coated with Ice Ban™ (a commercial, grain-based anti-icing/anti-freezing agent), at a mass ratio of approximately 24:1, then mixed with road sand at a ratio of 5 lbs per ton of sand (5.67 kg per metric ton);
- *Cal Ban*, 38% aqueous calcium chloride solution and Ice Ban™ at a mass ratio of approximately 16:1, mixed with road sand at a ratio of 8 gallons per ton of sand (33.4 liters per metric ton);

- *C-50*, 38% aqueous calcium chloride solution and Ice Ban™ at a mass ratio of approximately 1:1, mixed with road sand at a ratio of 8 gallons per ton of sand (33.4 liters per metric ton);

- *M-50*, 30% aqueous magnesium chloride solution and Ice Ban™ at a mass ratio of approximately 1:1, mixed with road sand at a ratio of 8 gallons per ton of sand (33.4 liters per metric ton); and

- *FreezGard Zero*, 30% aqueous magnesium chloride solution and Ice Ban™ at a mass ratio of approximately 24:1, mixed with road sand at a ratio of 8 gallons per ton of sand (33.4 liters per metric ton).

In the column leach tests, road sand was mixed with the six anti-freezing agents in ratios approximately equal to those in the field study. De-ionized water was then leached through the columns and leachate samples were collected at specified pore volumes. The leachate samples were then analyzed for several appropriate physical and chemical parameters based on the compositions of the six different agents. Analysis of leachate samples collected through the first seven pore volumes indicated product losses upward of 50%. Evaluation of the column leach data suggests the following:

- Salt and Salt Ban exhibited the greatest losses of both anions (64.17% and 66.17%, respectively), and cations (72.67% and 78.05%, respectively).

- FreezGard Zero, a magnesium chloride based anti-freezing agent, closely followed Salt and Salt Ban in anion (63.38%) and cation (67.08%) losses.

- C-50, Cal Ban, and M-50 exhibited similar but lower anion (39.20% to 49.23%) and cation (57.29% to 66.28%) losses than the aforementioned.

- Overall, column test data suggest that the majority of leaching will occur within the first four pore volumes, regardless of the anti-freezing agent.

In the field tests, a series of 12 test stockpiles were constructed in six stockpile pairs, each pair amended with one of the six different anti-freezing agents. One stockpile of each pair was then covered with the SS-1 asphalt emulsion. Core samples were to be taken from these various stockpiles and the depth of frost rind and interior freezing of the sand compared: (1) between the covered and uncovered stockpile for each anti-freezing agent, and, (2) among all six piles for all the anti-freezing agents. However, weather conditions during the winter of 1999-2000 were relatively mild and temperatures were not cold enough to freeze the test stockpiles. Consequently, no workability testing was conducted on these 12 test stockpiles during the winter of 1999-2000.

Colder weather conditions occurred during the winter of 2000-2001 that allowed Maxim and MDT personnel to complete the workability tests. Results of the workability tests indicate the following:

- Frost rind measurements indicate that Salt Ban is the most effective agent at preventing freezing of stockpile outer surfaces followed in order by Salt, FreezGard, M-50, C-50, and Cal Ban.

- Sieve analysis results indicated that Salt is the most effective agent at preventing freezing within the interiors of the stockpiles followed in order by Salt Ban, M-50, Cal Ban, FreezGard, and C-50.

The evaluation of SS-1 as a cover material included a stockpile leach study. The study included the construction of two stockpiles of approximately 7 cubic yards each on plastic lined leach pads that were plumbed into 500 gallon (1,890 liters) Nalgene collection tanks. One of the leach piles was covered with an asphalt emulsion (Slow Set 1, (SS-1)) and the other was left uncovered. The volume of leachate in the two tanks was then monitored from November 1999, through April 2000. While it was anticipated that the uncovered stockpile would leach more precipitation than the covered stockpile, the opposite was in fact observed. Specifically, the asphalt covered stockpile leached a total of approximately 430 gallons (1,627.7 liters) throughout the test period, while the uncovered pile leached only 141 gallons (533.7 liters).

In October 2000, the two leach stockpiles were dismantled and the leach pads inspected. Although no obvious reasons were found to indicate why the covered stockpile leached more water than the uncovered stockpile, it was suspected that precipitation water was gathering and infiltrating around the berm at the base of the piles. Two new stockpiles were constructed on the leach pads, the berms were eliminated, and the experiment was run again through the winter of 2000-2001. By April 2001, the covered leach stockpile leached approximately 98 gallons (371.0 liters) and the uncovered stockpile leached only 43 gallons (162.8 liters), again indicating that the asphalt cover contributes to stockpile leaching.

Finally, the following statements summarize the findings and conclusions of the ASM Research Project:

- Among the chemicals tested, sodium chloride based additives exhibit the greatest propensity to leach cations, anions, and overall.

- Frost rind measurements and sieve analysis results indicated that Salt Ban and Salt were the most effective at preventing stockpile freezing and maintaining workability.

- SS-1 asphalt emulsion used as a stockpile cover material does not appear to prevent or slow the leaching of chemical anti-freezing additives, and was not effective at preventing stockpile freezing.

- Overall rating or ranking of the six anti-freezing agents which considered leaching tendencies, and stockpile workability indicated that Salt, Salt Ban, and M-50 exhibited the greatest advantages in their use as stockpile additives.

TABLE OF CONTENTS

Page

TECHNICAL REPORT DOCUMENTATION PAGE iii

ACKNOWLEDGEMENTS iv

PREFACE v

EXECUTIVE SUMMARY vi

1.0 INTRODUCTION 1
1.1 Project Background 1
1.2 Project Objectives 1
1.3 Project Approach 1

2.0 MATERIALS AND METHODS 3
1.1 Anti-Freezing Agents 3
1.2 Stockpile Cover 3
2.3 Bench-Scale Column Tests 3
2.3.1 Column Test Design and Setup 4
2.3.2 Column Compositions 4
2.3.3 Column Construction 6
2.3.4 Solution Addition 7
2.3.5 Data Collection 7
2.4 Bozeman Pass Stockpile Tests 9
2.4.1 Weather Monitoring 9
2.4.2 Experimental Stockpiles 9
2.4.3 Workability Test Stockpiles 10
2.4.4 Stockpile Asphalt Cover 11
2.4.5 Stockpile/Leachate Collection Systems 13
2.4.6 Workability Test Stockpile Sand Sampling Device 13
2.4.7 Flow Characteristics Evaluation 16

3.0 FINDINGS AND INTERPRETATIONS 17
3.1 Bench-Scale Column Tests 17
3.1.1 Untreated Sand Physical Data 17
3.1.2 Untreated and Treated Sand Chemical Data 17
3.1.3 Column Effluent Direct Measurement Data 18
3.1.4 Column Effluent Visual and Odor Characteristics 22
3.1.5 Column Sand Subsidence 23
3.1.6 Effluent Chemical Data 23
3.1.7 Raw Laboratory Data 31
3.1.8 Mass Estimate Data 32
3.2 Bozeman Pass Stockpile Tests 33
3.2.1 Weather Monitoring 33
3.2.2 Stockpile Leach Collection System 33
3.2.3 Workability Evaluation 38

4.0 SUMMARY AND CONCLUSIONS 45
4.1 Leach Extraction 45
4.2 Workability 45
4.3 SS-1 Cover Evaluation 46
4.4 Overall Rating 46

5.0 GLOSSARY 47

TABLE OF CONTENTS (continued)

Page

LIST OF TABLES

TABLE 1 Test Column Compositions 5
TABLE 2 Summary of Column Study Anti-Freezing Agent Laboratory Analytes 6
TABLE 3 Bozeman Pass Workability Test Stockpile Compositions 11
TABLE 4 Summary of Column Test Soil Analytical Data 18
TABLE 5 Summary of Column Tests Leachate Physical Parameter Data 19
TABLE 6 Column Leachate Analyte Concentrations 24
TABLE 7 Leach Column Initial Mass Composition Estimates 25
TABLE 8 Column Leachate Ionic Species Mass Balance Estimates 26
TABLE 9 Column Leachate Ionic Species Mass Balance Estimates Summary 27
TABLE 10 Percent Cations and Anions Leached From Columns Through Pore Volume 7 33
TABLE 11 Precipitation and Temperature Summary 34
TABLE 12 1999-2000 Leach Stockpile Collection Tanks Water Levels and Volumes 34
TABLE 13 Stockpile Workability Results 40,41,42
TABLE 14 Stockpile Freezing and Workability Results Summary 43
TABLE 15 Average Anti-Freezing and Workability Indices 44
TABLE 16 Anti-Freezing Agent Rankings 46

LIST OF FIGURES

FIGURE 1 Schematic of Test Column 8
FIGURE 2 Stockpile Configuration 12
FIGURE 3 Schematic of Leachate Collection System - Side View 14
FIGURE 4 Schematic of Leachate Collection System - Plan View 15
FIGURE 5 Roadsalt Column Test pH 20
FIGURE 6 Roadsalt Column Test EC 21
FIGURE 7 Ionic Species Mass Balance Estimates Data, Pore Volumes 1-3 28
FIGURE 8 Ionic Species Mass Balance Estimates Data, Pore Volumes 1-5 29
FIGURE 9 Ionic Species Mass Balance Estimates Data, Pore Volumes 1-7 30
FIGURE 10 Bozeman Pass Daily Precipitation Totals, 1999-2000 and 2000-2001 35
FIGURE 11 Bozeman Pass Mean Daily Temperatures, 1999-2000 and 2000-2001 36

LIST OF APPENDICES

APPENDIX A Manufacturer Product Information Data Sheets for Anti-Freezing Agents A-1
APPENDIX B Sand Aggregate Laboratory Report B-1
APPENDIX C Laboratory Analytical Reports for Column Test Sand Samples C-1
APPENDIX D Concentration vs. Pore Volume Graphs – Column Leach Extraction Data D-1
APPENDIX E Laboratory Analytical Reports – Column Test Leachate Samples E-1
APPENDIX F Laboratory Analytical Report – Covered Leach Test Stockpile Water F-1

1.0 INTRODUCTION

Montana Department of Transportation (MDT) assigned Maxim Technologies, Inc.® (Maxim) Task Order No. 305 during September 1999, directing Maxim to assist MDT with research of several highway anti-skid/anti-freezing agents. Known as the Anti-Skid Materials (ASM) Research Project, the study was intended to evaluate several factors that contribute to the effectiveness of chemical anti-freezing agents used in highway road sand. Maxim's role in the project was to conduct laboratory column leach tests and field scale workability, and leach volume analyses. This report provides discussions of the methods and results of bench-scale laboratory testing conducted at Maxim's office in Helena, and field testing conducted at an MDT stockpile site on Bozeman Pass.

1.1 Project Background

As part of its routine highway maintenance operations, MDT spreads sand as an anti-skid material on ice covered highways during winter weather. This sand is stored at numerous stockpile sites throughout the state from which it is loaded into snowplow sander units and spread on icy roadways by MDT maintenance personnel on an as-needed basis.

Typically, MDT sand stockpiles are not covered and receive precipitation throughout the year. As a result, stockpiled sand accumulates moisture and is prone to freezing in cold weather. To prevent this freezing, MDT has historically mixed sodium chloride (salt) with sand during stockpiling. As an anti-freezing agent, not only does the salt enable the sand to be loaded from the stockpiles, but it also maintains certain flow characteristics enabling its even application to road surfaces.

While sodium chloride has generally proven effective as an anti-freezing agent, it has a tendency to leach from the uncovered stockpiles and can be environmentally problematic. Consequently, MDT is considering sand storage alternatives, and has decided to study the feasibility of (1) using alternative anti-freezing agents, and (2) applying cover material to the stockpiles. This study involved a series of both bench and field scale natural exposure experiments.

1.2 Project Objectives

Based on discussions with MDT, Maxim identified two principal objectives for the ASM Research Project:

1. Evaluate the effectiveness of alternative anti-freezing agents for use in sand stockpiles; and,

2. Evaluate the effectiveness of Slow Set 1 (SS-1), an asphalt emulsion, as a stockpile cover material.

1.3 Project Approach

To address the objectives identified above, a series of both laboratory and field experiments were conducted. Laboratory column leach extraction tests evaluated the propensity for the various anti-freezing agents to leach, and the quality of the leachate from each. Seven columns were packed with road sand amended with various anti-freezing agents. De-ionized (DI) water leached through the

columns was collected at regular intervals and submitted for laboratory analysis of several common parameters.

Field experiments evaluated the different anti-freezing agents in maintaining stockpile flow characteristics, also referred to as "workability", and the effectiveness of SS-1 as a cover material. Each stockpile pair was amended with a different anti-freezing agent, and one stockpile of each pair was then covered with an asphalt emulsion. Workability was evaluated in the various stockpiles by collecting core samples and comparing the depth of the frost rind and the amount of frozen sand retained in a 3/8-inch (0.95 cm) sieve analysis.

To evaluate the effectiveness of an asphalt emulsion for covering stockpiles, two leach pads were constructed in which the collection basins were plumbed into large collection tanks. Two uniform stockpiles were then constructed on the leach pads, one of which was covered with an asphalt emulsion. The approach to this study was to measure and compare the volume of natural precipitation water leaching through the two stockpiles.

2.0 MATERIALS AND METHODS

This section of the ASM Research Project report provides descriptions of materials evaluated and methods used to evaluate those materials. MDT determined which anti-freezing agents were used in the study based on proven effectiveness of roadway deicers and relative cost. Evaluation methods were developed through the cooperative efforts of MDT, Maxim, Dust Chem, and others.

2.1 Anti-Freezing Agents

Six different anti-freezing agents were selected for evaluation in this investigation. These anti-freezing agents consisted of a variety of commercially available chemicals that were applied either as pure substances or as mixtures. Manufacturer product information data sheets for the majority of the six agents are provided in Appendix A. The six agents used in this study are:

- Salt (provided by Doug Andrus Distributing Inc., Idaho Falls, Idaho), is industrial grade, crystalline sodium chloride (NaCl) that MDT mixes with sand at 5 percent by weight (5 wt%) and uses as their anti-skid material, with the salt serving as the anti-freezing agent.

- FreezGard, also known as FreezGard Zero (Great Salt Lake Minerals Corporation, Ogden, Utah), is a 30% aqueous magnesium chloride ($MgCl_2$) solution that MDT uses for deicing purposes. It is applied directly to ice and snow-packed highway surfaces.

- Salt Ban is a mixture of sodium chloride salt and a commercial, grain-based anti-icing/anti-freezing agent known as Ice Ban™ (Ice Ban America, Inc., North Palm Beach, Florida).

- Cal Ban (Liquidow Armor Deicer, The Dow Chemical Company, Midland, Michigan) is a mixture of 38 wt% aqueous calcium chloride ($CaCl_2$) and 6 wt% Ice Ban™.

- C-50 is a mixture of equal parts of a 38 wt% aqueous calcium chloride solution (Liquidow Technical Grade Calcium Chloride Solution, The Dow Chemical Company, Midland, Michigan) and Ice Ban™.

- M-50 is a mixture of equal parts of 30 wt% aqueous magnesium chloride ($MgCl_2$) solution (FreezGard) and Ice Ban™.

2.2 Stockpile Cover

Stockpile cover material evaluated in this study was an asphalt emulsion known as SS-1 (Slow Set). This material is an emulsion consisting of 50% water and 50% road oil, and is commonly used in highway maintenance applications.

2.3 Bench-Scale Column Tests

The laboratory column testing program was designed to assess the characteristics of leachate that would be expected to exit stockpiles under field conditions. A direct relationship between test columns and stockpiles was theoretically established by attempting to mimic stockpile compositions, compaction, and

precipitation. The ensuing discussion of bench-scale column testing provides details that establish the column-stockpile relationship.

Moving the leachate investigation into the laboratory allowed control of climatic variables, including precipitation application rates, precipitation chemistry, and temperature regime. No standard procedures exist for design of this type of column test. As a result, Maxim collaborated with MDT and DustChem to establish test parameters and procedures.

2.3.1 Column Test Design and Setup

Maxim personnel constructed seven columns using clear PVC plastic tubes, 6 inches (15.2 cm) in diameter and 5 feet (152.4 cm) tall, with inlet ports in the top and bottom of each. Solutions were applied to the columns continuously using a peristaltic pump system. Steady influent delivery rates resulted in consistent temporal leaching rate data.

2.3.2 Column Compositions

Compositions of amended sand in the seven columns are discussed below and are summarized in Table 1. A sample of the untreated sand was collected for sieve and moisture content analyses at Maxim's laboratory in Helena. The report of those analyses is provided in Appendix B and indicates that 100% of the sample passed the 3/8-inch sieve and exhibited a moisture content of 3.3%. In all columns, sand was added to a total depth of approximately 42 inches (approximately 107 cm). With a column diameter of 6 inches, the volume of sand in each column was approximately 0.69 cubic feet (ft^3; 19.53 liters). At an approximate porosity of 30%, one pore volume is equal to approximately 5.859 liters (L).

- *Column 1, Control.* This column consisted of untreated road sand and served as a control column.

- *Column 2, Salt.* The field ratio of crystalline salt to sand was 100 lbs (45.4 kg) per ton (907.2 kg). The corresponding column study ratio was 5 lbs of crystalline salt (2.27 kg) per 100 lbs of sand (45.4 kg).

- *Column 3, Salt Ban.* The field ratio of Salt Ban to sand was 100 lbs (45.4 kg) per ton (907.2 kg), with Salt Ban consisting of crystalline salt blended with Ice Ban™ at a mass ratio of 24:1. This resulted in 8 gallons (30.3 L) of Ice Ban™ to one ton (907.2 kg) of crystalline salt (based on an Ice Ban™ density of 1.25 g/ml as provided by DustChem). The corresponding column study ratio was 5 lbs (2.27 kg) of crystalline salt blended with approximately 0.02 gallons (76 ml) of Ice Ban™, then mixed with 100 lbs (45.4 kg) of sand.

- *Column 4, C-50.* The field ratio of C-50 to sand was approximately 8 gallons (30.3 L) per ton (907.2 kg), with C-50 consisting of 38% aqueous calcium chloride and Ice Ban™ blended at a volume ratio of 1:1. The ratio used in the column study was inadvertently slightly lower at 7.75 gallons (29.3 L) of C-50 per ton (907.2 kg) of sand. This corresponded to 0.387 gallons (1465 ml) of C-50 mixed with 100 lbs (45.4 kg) of sand, with C-50 consisting of approximately 0.194 gallons (734 ml) of each 38% aqueous calcium chloride and Ice Ban™.

- *Column 5, Cal Ban.* The field ratio of Cal Ban to sand was approximately 8 gallons (30.3 L) per ton (907.2 kg), with Cal Ban consisting of 38% aqueous calcium chloride mixed with Ice Ban™ at a mass ratio of 16:1 (premixed). The ratio used in the column study was inadvertently slightly lower at 7.75 gallons (29.3 L) of Cal Ban per ton (907.2 kg) of sand, which corresponded to 0.387 gallons (1465 ml) of Cal Ban mixed with 100 lbs (45.4 kg) of sand.

- *Column 6, M-50.* The field ratio of M-50 to sand was approximately 8 gallons (30.3 L) per ton (907.2 kg), with M-50 consisting of 30% magnesium chloride and Ice Ban™ blended at volume ratio of 1:1. The ratio used in the column study was inadvertently slightly lower at 7.75 gallons (29.3 L) of M-50 per ton (907.2 kg) of sand, which corresponded to 0.387 gallons (1465 ml) of M-50 mixed with 100 lbs (45.4 kg) of sand, with M-50 consisting of approximately 0.194 gallons (734 ml) of each 30% aqueous magnesium chloride and Ice Ban™.

- *Column 7, FreezGard.* The field ratio of FreezGard to sand was approximately 8 gallons (30.3 L) per ton (907.2 kg), with FreezGard consisting of 30% aqueous magnesium chloride mixed with Ice Ban™ at a mass ratio of 24:1 (premixed). The ratio used in the column study was inadvertently slightly lower at 7.75 gallons (29.3 L) of Cal Ban per ton (907.2 kg) of sand, which corresponded to 0.387 gallons (1466 ml) of M-50 mixed with 100 lbs (45.4 kg) of sand.

Table 1 summarizes the seven columns and their contents.

TABLE 1
Test Column Compositions
MDT Anti-Skid Material Research Project

Column Number	Column Identification	Composition
1	Sand	Untreated highway road sand
2	Sodium Chloride	100 lbs (45.4 kg) road sand with 5 lbs (2.27 kg) of crystalline sodium chloride
3	Salt Ban	100 lbs (45.4 kg) road sand with 5 lbs (2.27 kg) of crystalline sodium chloride and 0.02 gal Ice Ban™
4	C-50	100 lbs (45.4 kg) road sand with 0.19 gal (734 ml) each calcium chloride solution and Ice Ban™
5	Cal Ban	100 lbs (45.4 kg) road sand with 0.39 gal (1465 ml) Cal Ban
6	M-50	100 lbs (45.4 kg) road sand with 0.19 gal (734 ml) each magnesium chloride solution and Ice Ban™
7	FreezGard Zero	100 lbs (45.4 kg) road sand with 0.39 gal (1465 ml) FreezGard

2.3.3 Column Construction

Several hundred pounds of untreated road sand were delivered to Maxim's Helena laboratory from the Bozeman Pass sand stockpile site during the fall of 1999. This sand is assumed to be representative of sand used statewide on Montana roadways. Prior to mixing the sand with the various anti-freezing agents, the sand pile was coned and quartered, and a representative sample collected for moisture analysis and particle size distribution. One hundred pound (45.4 kg) charges of sand were weighed and poured into a wheelbarrow to prepare for mixing with the various anti-freezing agents to be tested. All mixing and measuring equipment were rinsed between each charge to avoid cross contamination.

Prior to column loading, a layer of inert silica sand was placed in the bottom of each column to prevent migration of sand particles into a collection carboy. An equal volume of sand mixture 42 inches (106.7 cm) +/- 1/2 inch (1.27cm), was placed in each column. Since stockpiles are not compacted in the field, no compaction was done on the sand charges other than tapping column sidewalls with a rubber mallet to reduce sidewall friction effects. After the sand charges were placed in the columns, another layer of inert rock was put on top of the sand to serve as a diffuser of the applied water.

Maxim personnel collected a sample of the mixed material loaded in each of the individual columns for baseline analysis. Baseline parameters were consistent with those expected to be analyzed in test column effluent water samples. This list of analytes was developed with consultation provided by Northern Analytical Laboratories (NAL) following their review of constituent lists for the various anti-freezing agents being tested (Appendix A). These analytes and corresponding analytical methods are listed in Table 2.

TABLE 2
Summary of Column Study Anti-Freezing Agent Laboratory Analytes
MDT Anti-Skid Material Research Project

Parameter		EPA Method
Anions	Alkalinity Bicarbonate as HCO_3	2320B
	Alkalinity Carbonate as CO_3	"
	Alkalinity Total as $CaCO_3$	"
	Chloride as Cl	325.3
	Sulfate as SO_4	375.3
Cations	Calcium as Ca	6010B
	Magnesium as Mg	"
	Sodium as Na	"
Inorganic	Biochemical Oxygen Demand	405.1
	Chemical Oxygen Demand	410.1
	pH	150.1
	Total dissolved Solids	160.1
	Organic Carbon	S-9.10 MOD
Nutrients	Nitrate + Nitrite as N	353.2
	Phosphorous Total	365.2

2.3.4 Solution Addition

Column tests were conducted using deionized (DI) water to simulate precipitation. Based on characteristic precipitation totals, it was assumed that approximately 20 inches (50.8 cm) per year would be representative of average annual precipitation at sand stockpile facilities throughout Montana. Sand stockpiles are typically in place for up to two to three years, so the test was planned to deliver the equivalent of two to three years of simulated precipitation influent to each column. Calculations indicated that 464 milliliters (ml) of DI water would represent 1 inch of simulated precipitation on top of a sand charge in a 6-inch diameter column. Each column was connected to one of three dedicated, low-volume peristaltic pump heads (Cole-Palmer Instruments Co., Model 7553-80) delivering DI water 24 hours per day, seven days per week. The columns were plumbed to three different peristaltic pumps.

DI water was pumped into the top of each column through 0.8 millimeter (mm) diameter silicone tubing, and allowed to percolate through the sand material. The leached water then drained from the column through Tygon tubing into a high density polyethylene (HDPE) carboy. DI water used in the test was prepared in Maxim's Helena laboratory and NAL conducted confirmation chemical analyses. All plastic components, including pump heads and Tygon drain tubing, were rinsed with dilute nitric acid solution and DI water to reduce potential contamination. Figure 1 provides a schematic diagram of a test column.

The pumps were started on December 1, 1999, and application rates were set to approximately 10 to 13 ml per hour. Application rates were monitored every day for the first two weeks, and at least every two to three days throughout the test period. Room temperature was monitored at least every other day and found to fluctuate between 68° and 72° F (approximately 20° and 22° C). Based on an application rate of 10 to 13 ml per hour, and an estimated pore volume of approximately 5,859 ml in each of the columns, the time for effluent breakthrough was expected to take 450 to 550 hours. Actual breakthrough occurred in approximately 72 hours.

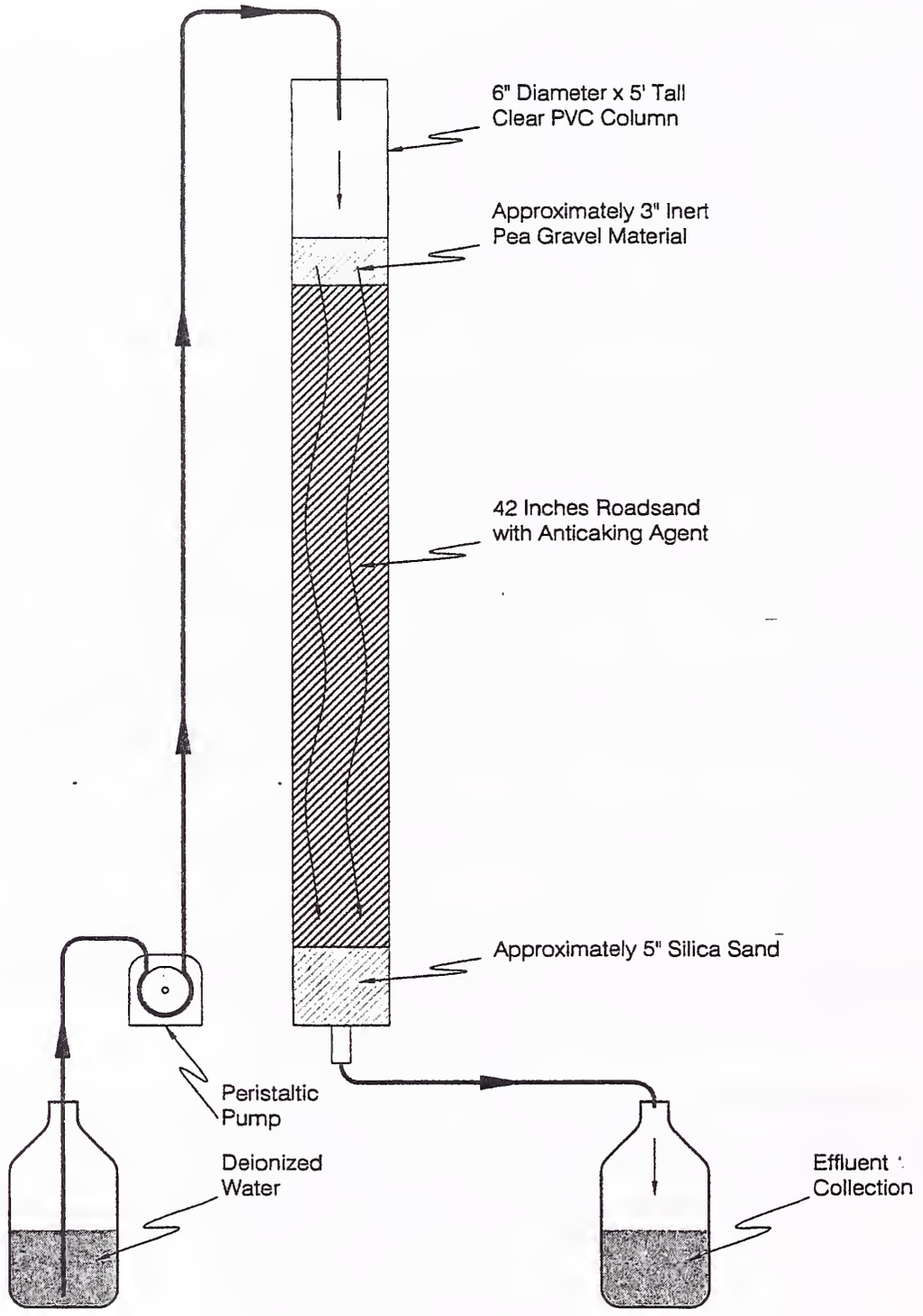
The first effluent breakthrough occurred on December 4, 1999. The short time period between starting DI water application and effluent indicated that "short-circuiting" or piping through the column material was occurring. This was likely due to the lack of compaction in the columns.

In order to maximize dispersal of DI water through the columns, Maxim began moving the water delivery tubes to different points on the material surface, and eventually plugged the end, and perforated and coiled the delivery tubing to spread water over a larger portion of the column surface. This technique apparently minimized the "piping" effect of DI water through the column as evidenced by the slowing of pore volume returns, and a wetting front followed by saturation of the column that was observed through the clear PVC.

2.3.5 Data Collection

MDT and Maxim planned to collect effluent samples at intervals representing effluent precipitation returns of 1 inch (2.54 cm), 5 inches (12.7 cm), 10 inches (25.4 cm), and every 5 inches (12.7 cm) thereafter until the test was terminated. However, analytical requirements dictated the collection of a minimum of 0.4 gal (1514 ml) of effluent (approximately equivalent to 3 inches (7.6 cm)) per sample. Therefore, the sample collection plan was modified to allow collection and submission of sufficient sample volume. The first

mdt\bzopass\column.dwg



Schematic of Test Column
Montana Department of Transportation
Anti-Skid Material Research Project
Bozeman Pass
FIGURE 1

Not To Scale

MAXIM 9911852.100

effluent "pore volume" collected was just over 3 inches of return; pore volume two (PV-2) was actually collected at approximately 7 inches (17.8 cm) of effluent return, and pore volume three (PV-3) was collected at approximately 10 inches (25.4 cm) of effluent return. Subsequent sampling was conducted at 5 inch (12.7 cm) intervals as originally planned until pore volume eight (PV-8), which was combined with pore volume nine (PV-9) and shipped as a composite sample. During sample collection, Maxim measured pH and electrical conductivity. Once the appropriate volume of sample was collected, samples were preserved, labeled and shipped to NAL for laboratory analysis of parameters listed in Table 2.

2.4 Bozeman Pass Stockpile Tests

The field study component of the ASM Research Project was conducted at MDT's stockpile site located at the top of Bozeman Pass approximately 13 miles east of Bozeman on Interstate Highway I-90. This facility is used for general highway maintenance operations. While most of the site is undeveloped, the site does have an equipment storage shed with electric power, an asphalt mixing floor, and a sand stockpile. The site is also equipped with an MDT Remote Weather Information System (RWIS), which is an automated meteorological data acquisition system.

The field component of the project was conducted over two winters. Originally, the project was intended to be conducted only through the winter of 1999-2000. However, this was an unusually warm winter and temperatures were not cold enough to freeze the test stockpiles. Therefore, the field study was continued during the winter of 2000-2001.

2.4.1 Weather Monitoring

Two key meteorological parameters were evaluated as part of the field study, precipitation and temperature. These parameters were monitored automatically at MDT's RWIS and evaluated to identify trends in weather patterns as well as provide precipitation and temperature data for specific monitoring and sampling events. For meteorological data acquisition purposes, the test period was defined as the period from November 1 through April 30 for each of the two winters.

2.4.2 Experimental Stockpiles

To address workability, and leachate study objectives, MDT and Maxim identified the following tasks:

- Design and construct a stockpile/leachate collection system, and develop a protocol for monitoring leachate volumes;
- Design a stockpile configuration, and develop a sampling and analysis protocol that would provide appropriate data from which to evaluate sand workability; and,
- Develop a protocol for monitoring weather conditions.

Twelve (12) test stockpiles were initially constructed with the intended purpose of evaluating workability. However, because the winter of 1999-2000 was unusually warm and none of the stockpiles froze adequately for sampling, the 12 test stockpiles remained intact at the site throughout the summer and fall of 2000 in anticipation of sampling during the winter of 2000-2001. During the fall of 2000, Maxim and

MDT constructed two additional test stockpiles at the site. These were amended with sodium chloride in the same ratio as the two original sodium chloride stockpiles. The purpose of these two new sodium chloride stockpiles was to evaluate, through comparison, the effects of a full year of weathering on the stockpiles. Sodium chloride was selected because of its availability.

To evaluate the effectiveness of an asphalt stockpile cover, Maxim and MDT constructed two leachate stockpiles in October 1999. Leachate volumes were monitored throughout the winter of 1999-2000. In October 2000, these two leachate stockpiles were dismantled, two new leachate stockpiles constructed, and leachate volumes were again monitored throughout the winter of 2000-2001.

2.4.3 Workability Test Stockpiles

The 12 workability test stockpiles were constructed in pairs, each pair having the same anti-freezing agent composition; however, one test stockpile of each pair was covered with asphalt. Each test stockpile had an average mass of approximately 20 tons (18,144 kg).

The sand for each of the 14 test stockpiles was then amended with the various anti-freezing agents by mixing on an asphalt mat with a front-end loader. The sand was first spread out on the mat and the agents then applied and mixed. Crystalline sodium chloride salt was applied using a tractor bucket. Ice Ban™, Cal Ban, C-50 and M-50 were spray applied from portable transport tanks. FreezGard was spray applied using an MDT deicing vehicle. The piles were constructed in an elongated geometrical configuration on an east-west axis to provide maximum north facing and south facing exposure for analyzing solar effects on workability. Compositions of the 14 test stockpiles are listed in Table 3.

Upon construction of the workability stockpiles, the dimensions were measured and averaged. Dimensions of the stockpiles are: 22 ft (6.70 m) long, 12 ft (3.66 m) wide, and 4.1 ft (1.25 m) high. Each workability test stockpile was approximately 15 yd^3, weighed approximately 20 tons, and had an exposed surface area of approximately 140 ft^2.

TABLE 3 Bozeman Pass Workability Test Stockpile Compositions MDT Anti-Skid Material Research Project	
Test Stockpile	**Composition**
1 & 2	15 yd^3 (11.5 m^3) road sand mixed with approximately 160 gallons (605.6 liters) of C-50.
3 & 4	15 yd^3 road sand (11.5 m^3) mixed with approximately 160 gallons (605.6 liters) of Cal Ban.
5 & 6	15 yd^3 road sand (11.5 m^3) mixed with approximately 0.9 yd^3 salt (0.67 m^3) amended with 8 gal (30.3 liters) Ice Ban™.
7 & 8	15 yd^3 road sand (11.5 m^3) mixed with approximately 0.9 yd^3 (0.67 m^3) salt.
9 & 10	15 yd^3 road sand (11.5 m^3) mixed with approximately 160 gal (605.6 liters) of FreezGard.
11 & 12	15 yd^3 road sand (11.5 m^3) mixed with approximately 160 gallons (605.6 liters) of M-50.
13 & 14	15 yd^3 road sand (11.5 m^3) mixed with approximately 0.9 yd^3 (0.67 m^3) crystalline salt (added to the site in November 2000)

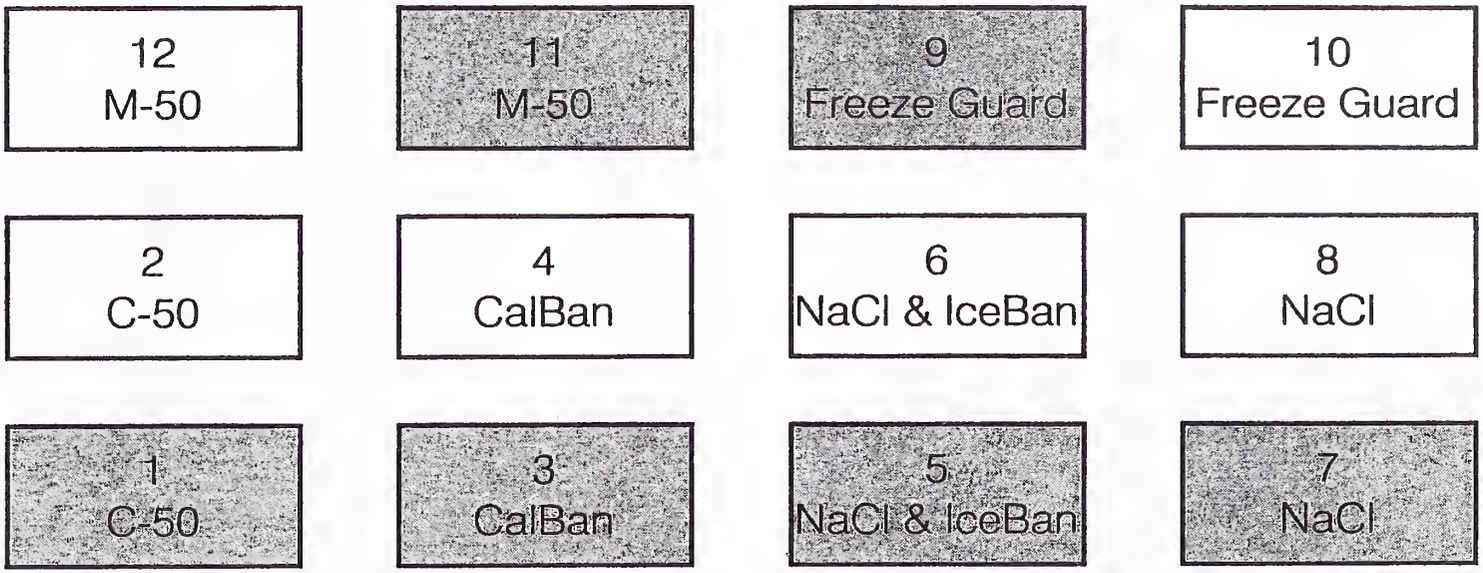
2.4.4 Stockpile Asphalt Cover

Following construction, one of each workability test stockpile pair was covered with the asphalt emulsion, (SS-1) that consists of 50% road oil and 50% water. This emulsion was applied directly to one stockpile of each of the seven pairs using a MDT road oil distributor in which the emulsion is applied hot and solidifies upon cooling.

Six of the original 12 workability stockpiles were initially coated with SS-1 on October 27, 1999. With settling of the sand, fractures appeared in several of the stockpiles. Consequently, on November 1, 1999, asphalt was re-applied to those piles that had fractures. The two additional stockpiles were coated on October 23, 2000. The stockpiles were identified by number, with the odd numbered stockpiles being covered with asphalt. A schematic diagram showing the configurations of these stockpiles at the site is shown in Figure 2.

Following application of the asphalt, a Jersey Rail barricade was installed around all 12 workability test stockpiles to protect them against equipment damage. The two additional stockpiles constructed in October 2000 were also located within this barricaded perimeter.

mdt\bzopass\stokpile.dwg



Indicates asphalt covered stockpile

12

N

Stockpile Configuration
Montana Department of Transportation
Anti-Skid Material Research Project
Bozeman Pass
FIGURE 2

MAXIM 9911852.100

2.4.5 Stockpile/Leachate Collection Systems

The two stockpiles used for evaluating cover efficiency were individually constructed on separate leach pads with leachate collection systems. As-built drawings of the leachate collection systems are provided in Figures 3 and 4. These two stockpiles were built at the edge of a bluff bank with 500-gallon (1,893 liter) leachate collection tanks at the bottom of the bank. With the top of the collection tanks approximately 5 feet (1.52 m) below the bottom of the leach pads, this configuration provided for gravity drainage of the leach pads. Road sand was placed around the base of the two collection tanks for stability. The two leach stockpiles were positioned on an approximate east-west axis with the drainage piping and collection tanks located on the south side of each stockpile.

The leach pads were contoured with road sand into the sump, over which was laid heavy plastic sheeting. All plumbing was constructed with schedule 40 2-inch diameter PVC. The drainage piping that extended from the sumps into the collection tanks was wrapped with heat tape and insulation to prevent freezing. The heat tape was later connected to electric outlets that MDT installed at the leach stockpiles.

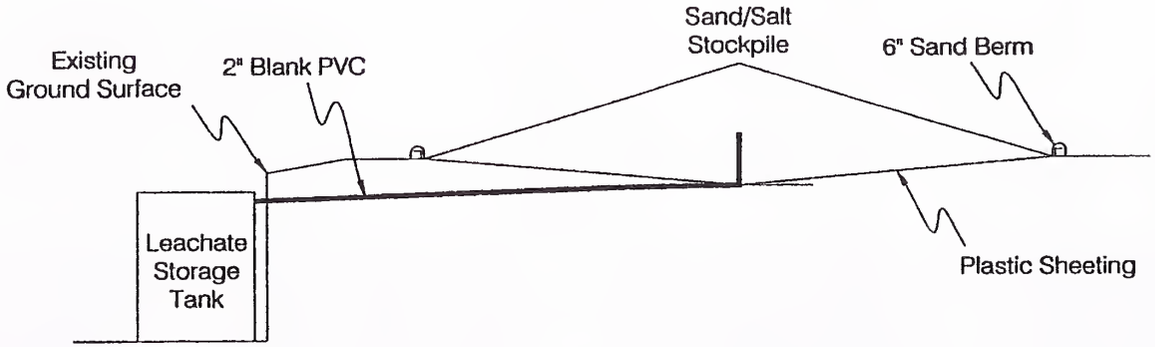
Berms were constructed around the outside of the leach pads and the excess plastic removed. The two leachate test stockpiles were then built using approximately 6 cubic yards (4.6 m^3) of a 5% salted road sand that was taken from an existing stockpile at the site. These leachate test stockpiles were constructed between October 27 and November 1, 1999. Asphalt was applied to the east stockpile on November 1, 1999.

The two original leachate test stockpiles were dismantled and the leachate collection systems inspected in October 2000. Two new leachate test stockpiles were then constructed on the existing leach pads without berms around the base. Removal of the berms was intended to prevent precipitation water from collecting at the base of the stockpiles. These two stockpiles remained intact throughout the winter of 2000-2001.

2.4.6 Workability Test Stockpile Sand Sampling Device

MDT personnel developed a split-spoon type core-sampling device powered by a ½-inch electric drill for the purposes of collecting core samples from the workability stockpiles. Several different techniques, support equipment, and angles were tried. Maxim personnel found that stockpiles could be adequately drilled by hand at an angle perpendicular to the face of the stockpile. Although subjective, Maxim personnel also found that completely frozen, partially frozen, and completely unfrozen sand intervals could be detected based on the difficulty or ease of drilling. These observations were substantiated by actual measurements that are discussed below. Drilling into all stockpiles proceeded until completely unfrozen material was encountered. The drill cuttings were retained for flow characteristics evaluation.

mdt\bzopass\asbuilt1.dwg



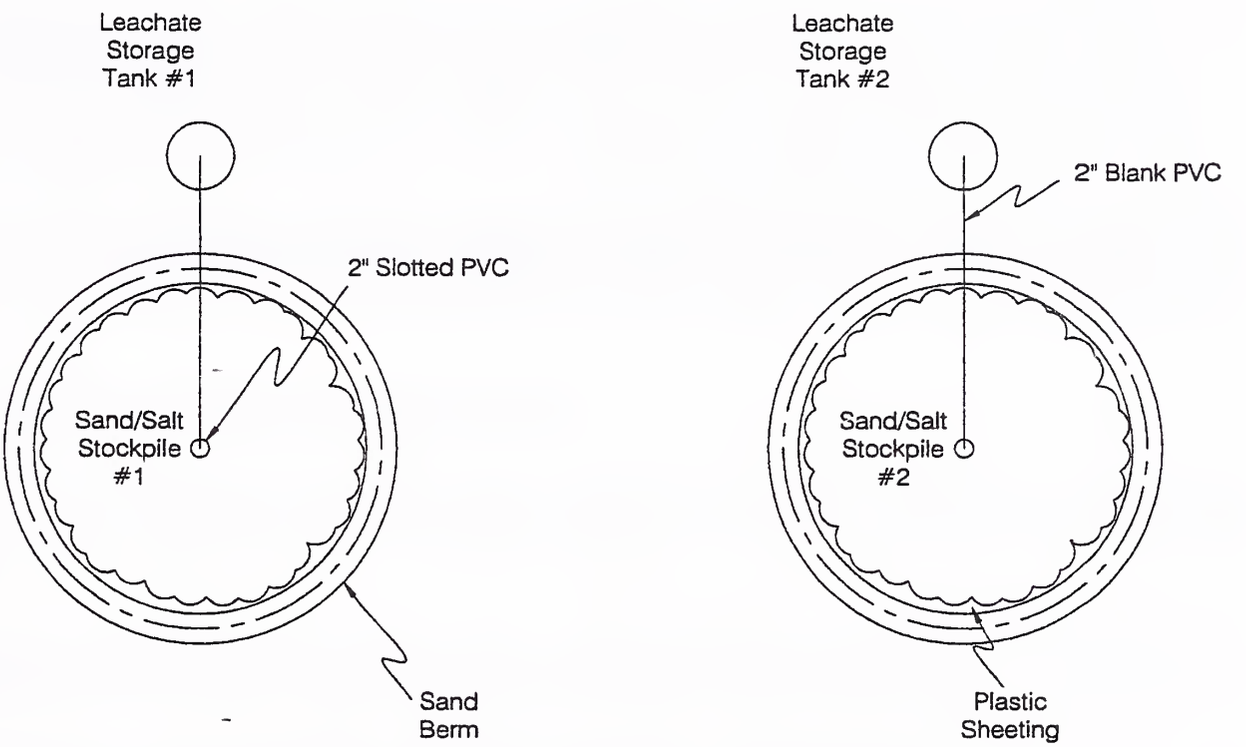
SIDE VIEW

Scale: 1"=8'-0"

Schematic of Leachate Collection System - Side View
Montana Department of Transportation
Anti-Skid Material Research Project
Bozeman Pass
FIGURE 3

MAXIM 9911852.100

mdt\bzopass\asbuilt.dwg



PLAN VIEW

Scale: 1"=14'-0"

Schematic of Leachate Collection System
Montana Department of Transportation
Anti-Skid Material Research Project
Bozeman Pass
FIGURE 4

MAXIM 9911852.100

2.4.7 Flow Characteristics Evaluation

MDT and Maxim personnel developed three criteria to evaluate the workability of the various sand/ant-freezing agent mixtures. These criteria are discussed below:

- Two samples, one from the north face and one from the south face of the stockpiles were collected using the core-sampling device during each of three monitoring events. Upon removal of the core sample, the depth of the frost rind was measured by extending a tape measure into the open borehole.

- All drilled material from each core was combined and weighed using an electronic balance. This material was then subjected to a 3/8-inch sieve analysis, and the mass passing was then weighed and the mass retained calculated. The retained material was then visually inspected to determine its nature, i.e., frozen sand, gravel, and/or asphalt.

- A portion of passing sand from each sieve analysis was containerized and taken to the MDT materials laboratory in Bozeman where moisture content analyses were conducted.

3.0 FINDINGS AND INTERPRETATIONS

The following sections present Maxim's findings and interpretations of data acquired from both the bench scale column studies and the field studies.

3.1 Bench-Scale Column Tests

Untreated sand used in the columns was analyzed for a variety of physical and chemical parameters to characterize the sand and to establish baseline or background characteristics for comparison to treated sand mixtures. Evaluation of the propensity of the anti-freezing agents to leach from treated sand was based on analysis of the aqueous effluent from the various columns.

3.1.1 Untreated Sand Physical Data

Results of sieve and moisture analyses conducted on an untreated sample of road sand are included in Appendix B. These results indicate that 100% of the sand sample passed a 3/8-inch screen, and a relatively low fraction of the sample (7.2%) passed the No. 200 screen. Moisture content was measured at 3.3% by weight.

3.1.2 Untreated and Treated Sand Chemical Data

Laboratory analytical results for samples of untreated sand used in the column studies are summarized in Table 4, and the corresponding laboratory report is presented in Appendix C. Data in Table 4 indicate the following:

- Untreated sand is moderately alkaline (pH 8.1) and calcium dominated. From a fertility standpoint, phosphorus content is high, and organic carbon content is low (less than 0.25%).
- As expected, Salt and Salt Ban treatments substantially increased sodium (about 15 times), and chloride concentrations (about 40 times) when compared to untreated sand.
- Treatment with M-50 resulted in the highest chloride concentration (31,700 milligrams per kilogram (mg/kg)) amongst the six additives.
- Treatment with C-50, Cal Ban, and M-50 resulted in only slight increases in calcium concentrations.
- Treatment with M-50 and FreezeGard resulted in 50% to 60% increases in magnesium concentrations.
- With the exception of Salt, treatment with all other additives resulted in notably higher carbonate/bicarbonate content.
- An increase in chemical oxygen demand (COD) was notable only for the C-50 and M-50 treatments, with the C-50 treatment about doubling the COD and the M-50 increasing the COD by 65%.
- Overall, organic carbon content for all treatments was less than 0.5%, and with one exception, was similar to that measured in untreated sand. Treatment with C-50 caused an approximate doubling of organic carbon content.

TABLE 4
Summary of Column Test Soil Analytical Data
MDT Anti-Skid Material Research Project

Parameter		Column						
		No. 1 (Untreated Sand)	No.2 (NaCl)	No. 3 (Salt Ban)	No. 4 (C-50)	No. 5 (Cal Ban)	No. 6 (M-50)	No. 7 (FreezGard)
Anions	HCO_3	7.4	4	23	118	23	275	27
	CO_3	0	0	0	0	0	0	0
	$CaCO_3$	6.0	3	19	96	19	225	22
Cations	Calcium	12,300	12,100	12,000	15,300	16,700	14,000	10,800
	Magnesium	4,510	4,340	4,220	4,080	4,380	6,180	7,190
	Sodium	1,030	15,400	16,100	1,200	950	1,440	1,070
Nutrients	Nitrate + Nitrite as N	11	13	16	72	11	66	10
	Phosphorous	860	790	830	740	780	800	780
Soil	Chloride	525	26,500	20,700	6,030	8,920	31,700	11,000
	COD	7,590	7,410	8,920	14,700	6,440	12,400	7,940
	Organic Carbon (%)	0.24	0.36	0.36	0.44	0.25	0.39	0.25
	pH (s.u.)	8.1	6.9	7.1	7.2	7.1	7.7	7.3
	Sulfate (%)	<0.01	<0.01	<0.01	0.02	<0.01	0.02	<0.01

Note: All concentrations reported in milligrams per kilogram (mg/kg) except where noted.
COD = Chemical Oxygen Demand

3.1.3 Column Effluent Direct Measurement Data

As effluent samples were collected, direct measurements were made for pH and electric conductance (EC) in the solutions. The results of these pH and EC measurements are listed in Table 5, and plots of these data are shown in Figures 5 and 6, respectively.

Laboratory analysis of DI water used to represent precipitation onto the column charges indicated a pH of 6.6. Review of pH values indicates a general increase in leachate pH with leaching. These increasing trends in pH are evident from the data graphically displayed in Figure 5, and are likely the result of continued presence of carbonate species coupled with progressively decreasing calcium concentrations. However, pH values remained relatively neutral to slightly alkaline, ranging generally between 6 and 9.

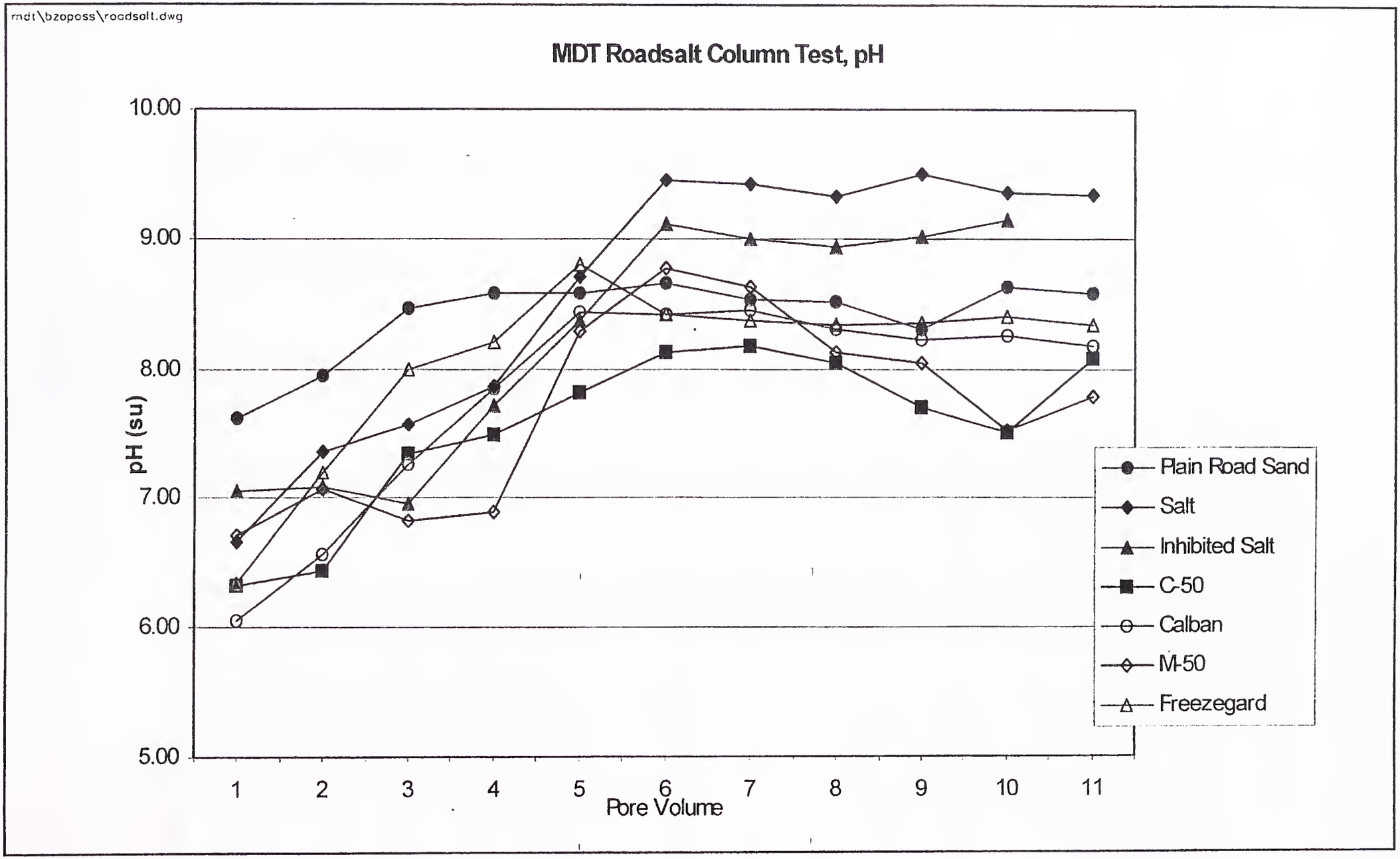
Electric conductance values progressively decreased with increasing leaching as shown in Figure 6. This trend is expected given that continued leaching will progressively reduce ionic species concentrations in soil water and thereby decrease its electric conductivity.

TABLE 5
SUMMARY OF COLUMN TESTS LEACHATE PHYSICAL PARAMETER DATA
MDT ANTI-SKID MATERIALS RESEARCH PROJECT

Column	Pore Vol. No.	Date	Effl. Vol. (in precip.)	Infl. Vol. In. precip.)	pH (su)	EC (mS)
1 Plain Sand	1	12/12/99	2.9	6.1	7.6	22.9
	2	12/20/99	6.8	10	7.9	5.2
	3	12/27/99	10.9	15.5	6.4	0.69
	4	1/4/00	15.6	18.5	9.5	0.78
	5	1/11/00	20.4	23.3	9.5	0.69
	6	1/19/00	26	29	8.7	0.69
	4	1/28/00	30.2	33.8	9.5	0.64
2 Salt	1	12/12/99	3.2	6.3	6.4	175.2
	2	12/20/99	7.2	10	7.1	160
	3	12/27/99	10.9	10	6.4	137
	4	1/4/00	15.6	19.1	6.4	121
	5	1/12/00	20.5	24.6	8.7	97.8
	6	1/19/00	26	29.9	9.5	5.6
	4	1/30/00	30.4	35.2	6.4	0.19
3 Salt Ban	1	12/12/99	3.3	6.3	7.6	22.9
	2	12/20/99	7	10	7.08	152
	3	12/27/99	10.4	15.5	7	146
	4	1/4/00	14.7	17.8	7.7	0.14
	5	1/19/00	19.9	23.3	6.4	0.69
	6	1/23/00	25.3	29.9	6.1	NM
	4	1/30/00	28.3	32.4	9	3
4 C-50	1	12/12/99	3.3	6.1	6.3	NM
	2	12/20/99	6.8	10.5	6.4	NM
	3	12/30/99	14.7	15.9	7.3	NM
	4	1/4/00	10.9	18.5	6.4	NM
	5	1/14/00	20.5	26.5	6.4	6.9
	6	1/23/00	25.3	32.5	6.4	NM
	4	1/30/00	25.3	36.9	8.2	NM
5 Cal Ban	1	12/12/99	3.6	6.1	6.1	84.4
	2	12/20/99	7.1	10.3	6.3	40.7
	3	12/30/99	10.9	19.1	NM	NM
	4	1/4/00	10.9	18.7	6.4	10.3
	5	1/14/00	20.4	28.7	6.4	1.06
	6	1/21/00	25.3	32.5	6.4	0.642
	4	1/30/00	30.9	35.8	6.3	0.59
6 M-50	1	12/12/99	3.2	6.4	8.2	NM
	2	12/20/99	7.5	11.1	7.1	NM
	3	12/27/99	10.9	15.5	6.3	NM
	4	1/4/00	15.1	18.5	9.5	NM
	5	1/19/00	19.9	24.1	8.3	NM
	6	1/23/00	25.3	29.9	6.3	NM
	4	1/30/00	28.3	34	6.3	NM
7 FreezGard Zero	4	12/12/99	3.1	6.3	6.4	65
	2	12/17/99	7.3	9.2	7.2	59.9
	3	12/23/99	10.2	12.6	9	14.5
	4	12/30/99	13.6	18.5	9.2	3.9
	5	1/19/00	21	24	6.4	0.75
	5	1/21/00	25.3	28.7	6.4	0.6
	7	1/28/00	29.4	32.5	8.3	0.53

NM: Parameter Not Measured

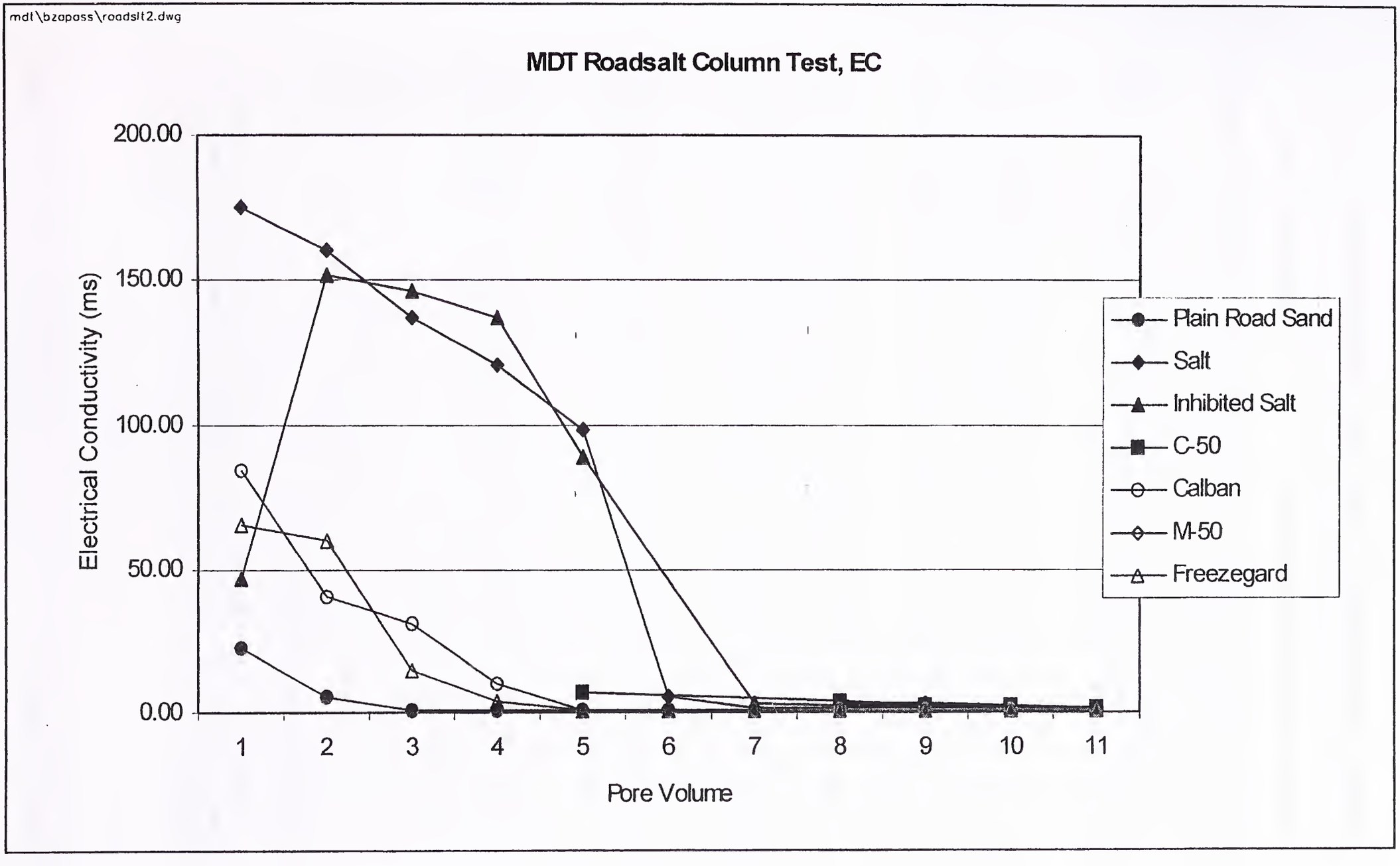
mdt\bzoposs\roadsalt.dwg



Roadsalt Column Test, pH
Montana Department of Transportation
Anti-Skid Material Research Project
Bozeman Pass, Montana
FIGURE 5

MAXIM TECHNOLOGIES INC® 9911852

mdt\bzapass\roadslt2.dwg



Roadsalt Column Test, EC
Montana Department of Transportation
Anti-Skid Material Research Project
Bozeman Pass, Montana
FIGURE 6

MAXIM TECHNOLOGIES INC® 9911852

3.1.4 Column Effluent Visual and Odor Characteristics

As effluent samples were collected, Maxim personnel made visual and odor observations of the aqueous samples. Following are summaries of these observations for the various columns.

- *Column 1, Untreated Sand.* Column 1 effluents were slightly yellow early in the test (PV-1, PV-2, and PV-3). As the test progressed, the effluents cleared up to a nearly clear appearance. No odor was detected and no sediments were noted in the effluent carboy.

- *Column 2, Crystalline Salt.* Column 2 returned clear effluent through the first two pore volumes (PV-1 and PV-2), but the third pore volume (PV-3) solution was slightly yellow although odorless. The color of the effluent samples continued to darken and became progressively less translucent with leaching, and by the seventh pore volume (PV-7) the solution was brown and completely opaque. The samples continued to be odorless, but some sediments and floating colloidal material were noted. The floating material quickly flocculated when the samples were preserved with sulfuric acid prior to shipment for laboratory analyses.

- *Column 3, Salt Ban.* Column 3 effluent was golden brown and nearly translucent in the first pore volume (PV-1), and had a slight odor resembling rotting vegetation. By the fourth pore volume (PV-4), the effluent became much darker brown, with some fine, dark-colored sediments and a slight odor. After the fourth pore volume, the effluent became progressively more translucent, and by the seventh pore volume (PV-7) appeared to be nearly the same color and translucence as the first pore volume sample (PV-1).

- *Column 4, C-50.* Column 4 effluent was very dark brown and cloudy with a strong odor of animal manure through all seven pore volumes, and sedimentation was observed throughout. Very late in the test (PV-10 and PV-11), the column effluents began to clear to a golden color with no odor and no sediment.

- *Column 5, Cal Ban.* The first pore volume of Column 5 effluent (PV-1) was somewhat yellow with a strong odor resembling rotting vegetation or animal manure. By the third pore volume (PV-3), the odor had decreased considerably, but the effluent color remained the same. Very fine white sediment was noted in the carboy throughout the test.

- *Column 6, M-50.* Column 6 effluent was nearly identical to that from Column 4, (i.e., very dark brown with a strong odor) with sedimentation observed through all pore volumes. As with Column 4, Column 6 samples began to clear late in the leaching procedure (i.e., PV-10 and PV-11), and both odors and sedimentation were no longer observed.

- *Column 7, FreezGard.* Column 7 effluent was clear to slightly yellow throughout the course of the test. There was no odor and no sediment. DI water percolated much faster through Column 7 than the other columns.

3.1.5 Column Sand Subsidence

All of the sand charges in the columns settled slightly (less than ¼- to ½-inch) with wetting. Columns 2 and 3 that contained the crystalline salt began settling more noticeably and quickly by December 15, 1999. They continued to settle until early February 2000. Total settlement was approximately 2 1/8 inches in Column 3, and 2 ½ inches in Column 2. This corresponded to approximately 5% and 6% by volume subsidence per column, respectively. The two columns were originally mixed to a salt/sand ratio of 5% by weight. It appears that the crystalline salt dissolved, decreasing the column volume by the volume of salt added.

3.1.6 Effluent Chemical Data

Evaluation of column leachate data involved an initial review of all column leach data collected through PV-7. These data are tabulated in Table 6, and corresponding graphs are included in Appendix D. Laboratory analytical reports for column leachate analyses are included in Appendix E.

Following this initial review, masses of various anti-freezing agents that were added to each of the treated columns prior to leaching were calculated. For these calculations, density values were used that were obtained from MDT and Dust Chem.

For each column, the amount of additive and the corresponding mass of the component ionic species were calculated, (i.e., sodium, calcium, magnesium and chloride). Included in the mass total for each species was the mass which leached from the untreated sand column (i.e., background mass). In addition, where applicable, the initial mass of the individual species contained in the added Ice Ban™ was added to the total species mass (in some cases the mass of ionic species in Ice Ban™ is negligible). All of the mass estimates are listed in Table 7.

The next step in the data evaluation was to calculate the total cumulative mass of each species that leached through PV-7. This simply involved multiplying the laboratory determined concentration for each species from each collection by the volume of leachate collected, then summing the mass values. These values are listed in Table 8. These leached mass values are under-estimates because they are based only on the mass in the collected leachate and do not account for the leachate that was not collected and analyzed. Therefore, the results may not be accurate on an absolute basis but should be valid on a relative basis. It should also be noted that in the few instances where a particular species parameter was not analyzed, the average of the previous and post mass values was used. These values have been italicized in Table 8.

The difference between the initial mass of each of the target species and that mass which had leached through PV-7, along with the percentages of mass leached and mass remaining, were calculated. These values are also listed in Table 8. Finally, these mass leach estimates were summarized in Table 9 and are graphed through pore volumes three, five, and seven in Figures 7, 8 and 9, respectively. The data tabulated in Table 8, and the corresponding data summary in Table 9 were used to evaluate the results of the column study.

Table 6
Column Leach Analyte Concentrations
MDT Anti-Skid Material Research Project
Column Leach Study
(All concentrations minus DI influent concentration, reported in milligrams per liter (mg/L))

	Sample ID	Sample Date	Leach Volume (liters)	HCO_3^- (mg/L)	CO_3^{-2} (mg/L)	$CaCO_3$ (mg/L)	Ca^{+2} (mg/L)	Mg^{+2} (mg/L)	Na^+ (mg/L)	SO_4^{-2} (mg/L)	Cl^- (mg/L)	BOD (mg/L)	COD (mg/L)	pH (s.u.)	TDS (mg/L)	TOC (mg/L)	$NO_3^- + NO_2^-$ (mg/L)	P (mg/L)
Sand	COL1PV1	12/12/99	1.35	72	0	59	2930	652	3440	48	11200	3	1190	7.6	20100	446	0.99	0.77
	COL1PV2	12/20/99	1.81	245	0	200	310	100	890	80	1890	3	992	8.1	3890	372	0.4	0.39
	COL1PV3	12/27/99	1.70	430	26	395	13	3	245	46	61	3	90	8.9	629	34	0.1	0.38
	COL1PV4	12/28/99	2.41	377	32	363	6	2	164	26	10	3	72	9	525	27	0.1	0.43
	COL1PV5	01/11/00	2.20	390	16	347	7	2	162	21	2	3	25	8.9	520	9	0.1	0.3
	COL1PV6	01/19/00	2.60	351	20	320	7	3	168	34	1	3	36	8.7	462	14	0.1	0.6
	COL1PV7	02/01/00	1.93	344	20	314	7	3	169	35	2	3	33	8.7	480	12	0.1	0.31
	Total		14.00															
NaCl	COL2PV1	12/12/99	1.50	0	0	0	7740	1300	116000	199	176000	3	4960	6.6	309000	1860	0.41	0.51
	COL2PV2	12/20/99	1.86	93	0	76			87000	165	131000	3	1980	7.5	190000	742	0.16	0.77
	COL2PV3	12/27/99	1.72	271	26	222	1550	350	69100	169	134000	3	3710	7.5	159000	1390	0.1	0.6
	COL2PV4	12/28/99	2.13	589	0	482	508	140	44700	142		3	1360	8.1	103000	510	0.16	0.91
	COL2PV5	01/11/00	2.32	1047	130	1069	124	28	33000	194	48200	3	2750	8.8	72700	1030	0.1	6.28
	COL2PV6	01/19/00	2.07	747	211	965	17	8	1450	100	1310	3	194	9.6	4290	73	0.05	3.98
	COL2PV7	02/01/00	2.51	565	146	707	23	36	542	151	157	3	89	9.5	2720	33	0.05	1.68
	Total		14.11															
Inhibited NaCl	COL3PV1	12/12/99	1.52	345	0	282	3260	622	85700	268	180000	83	9530	7.1	232000	3570	30	1.03
	COL3PV2	12/20/99	1.73	324	0	265			96900	330	154000	1860	5560	7	212000	2100	34	2.37
	COL3PV3	12/27/99	1.60	403	0	330	2870	760	93700	284	134000	1000	5430	7	232000	2040	32	0.79
	COL3PV4	12/28/99	2.22	886	0	726	625	274	64600	222		241	2530	7.6	143000	949	2.5	2.41
	COL3PV5	01/11/00	2.19	2457	0	2009	49	47	31700	246	44100	100	1270	8.5	71000	476	2.5	1.41
	COL3PV6	01/19/00	2.45	2517	211	2419	9	3	6230	105	6550	20	364	9	13400	136	0.92	3.99
	COL3PV7	02/01/00	1.67	1357	179	1409	4	1	930	42	152	3	81	9.2	2060	30	27	3.38
	Total		13.38															
C50	COL4PV1	12/12/99	1.51	3197	0	2619	26100	1720	7720	2100	51000	970	50800	6.3	133000	19000	250	8.38
	COL4PV2	12/20/99	1.63	3247	0	2659	23000		6730	1700	39300	1800	38900	6.7	113000	14600	2.5	9.19
	COL4PV3	12/30/99	1.81	4077	0	3339	10800	760	4190	922	25200	560	6880	6.9	55100	2580	0.59	3.04
	COL4PV4	12/31/99	2.26	913	0	748	1240	139	1030	311		200	2350	7.5	9320	881	0.5	1.84
	COL4PV5	01/14/00	2.28	863	0	707	536	71	608	265	1940	20	905	7.9	5680	339	1.68	0.89
	COL4PV6	01/19/00	2.41	830	0	680	250	40	458	196	846	13	970	8	3150	364	35.2	1
	COL4PV7	02/01/00	1.96	698	0	572	163	26	175	91	152	4	525	8.3	2070	197	220	0.38
	Total		13.86															
Caiban	COL5PV1	12/12/99	1.66	252	0	206	60900	1580	6090	239	107000	190	8930	6.2	177000	3350	1.2	5.94
	COL5PV2	12/20/99	1.65	173	0	141	22100		2640	128	42000	238	1190	6.6	62000	446	0.1	1.58
	COL5PV3	12/30/99	1.90	173	0	141	14200	390	1660	92	27100	105	796	7.3	40600	299	0.12	2.19
	COL5PV4	12/31/99	2.23	242	0	198	1940	59	450	65		16	253	7.8	7840	95	0.1	1.34
	COL5PV5	01/14/00	2.24	357	13	314	101	4	105	50	126	4	97	8.7	697	36	0.17	1.27
	COL5PV6	01/19/00	2.49	304	13	271	63	2	77	27	19	3	73	8.6	417	27	0.35	1.94
	COL5PV7	02/01/00	2.37	258	6	222	45	1	54	23	13	3	57	8.6	397	21	1.39	1.28
	Total		14.54															
M50	COL6PV1	12/12/99	1.51	5207	0	4269	5200	11500	7550	2250	46000	620	43700	6.8	112000	16400	110	12.68
	COL6PV2	12/20/99	1.99	4037	0	3309		6420		1030	22400	1800	17100	7.2	50200	6410	2.5	5.37
	COL6PV3	12/27/99	1.56	5987	0	4909	2330	6070	4040	977	20800	660	17400	6.8	52500	6530	1	3.53
	COL6PV4	12/28/99	1.95	5427	0	4449	1630	4430	3540	803		3600	17000	6.9	40200	6380	1.66	3.89
	COL6PV5	01/13/00	2.21	2437	0	1999	106	654	710	268	1950	902	1830	8.4	6430	686	1	3.53
	COL6PV6	01/19/00	2.54	1387	179	1439	43	172	216	170	204	200	471	8.8	2090	177	12.5	2.32
	COL6PV7	02/01/00	2.13	830	114	870	49	114	85	67	130	5	323	8.7	1820	121	140	0.76
	Total		13.89															
FreezeGard	COL7PV1	12/09/99	1.42	298	0	244	7840	41000	7470	853	181000	20	2580	6.5	260000	968	2	5.93
	COL7PV2	12/20/99	1.96	312	0	255		14000	3290	412	55100	8	2180	7.5	68800	818	1.1	0.72
	COL7PV3	12/23/99	1.35	318	0	260	530	2830	900	181	9850	3	362	8.2	16100	136	0.15	0.35
	COL7PV4	12/24/99	2.83	265	52	314	56	299	284	121		4	109	8.7	2360	41	0.1	0.35
	COL7PV5	01/13/00	2.20	331	13	293	22	36	92	33	59	3	47	8.8	521	18	0.1	0.23
	COL7PV6	01/19/00	2.05	291	0	265	8	30	84	18	15	3	34	8.7	331	13	0.08	0.3
	COL7PV7	02/01/00	2.33	265	13	238	6	26	69	10	12	3	31	8.7	324	12	0.37	0.15
	Total		14.14															
	DIINF	12/13/99		13	0	11	1	1	1	5	1	3	5	6.6	1220	2	0.1	0.02

SCI: Steel Coupon Index
DIINF: Deionized Water Influent Concentration

Table 7
Leach Column Initial Mass Composition Estimates
MDT Anti-Skid Material Research Project
(Total mass in mg per 42 inch column pack)

Column Number	Column ID	Anti-Freeze Additive				Total Ion Components			
		NaCl	$CaCl_2$	$MgCl_2$	Iceban	Na	Ca	Mg	Cl
1	Sand	--	--	--	--	--	--	--	--
2	Salted Sand	1,932,000	--	--	--	868,000	--	--	1,440,000
3	NaCl & Iceban	1,932,000	--	--	79,000	868,000	--	--	1,440,000
4	C-50	--	388,000	--	733,000	--	177,000	--	461,000
5	Calban	--	1,457,000	--	93,000	--	263,000	--	616,000
6	M-50	--	--	938,000	733,000	--	--	76,000	429,000
7	Freezgard	--	--	456,000	--	--	--	135,000	599,000

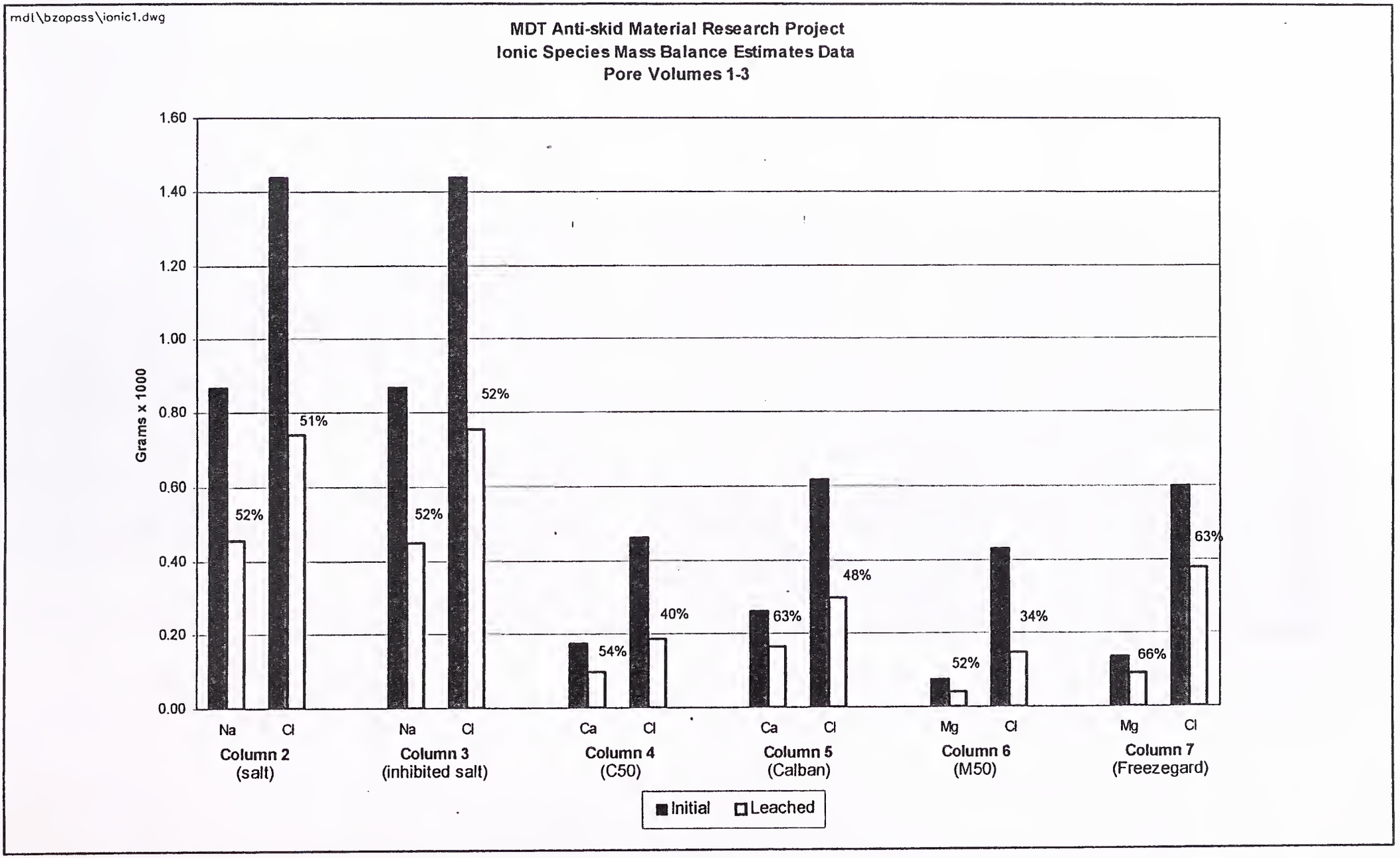
Table 8
Column Leachate Ionic Species Mass Balance Estimates
MDT Anti-Skid Material Research Project
Column Leach Study
(All mass values in mg)

	Sample ID	SampleDate	Leach Sample Volume (liters)	Ca^{+2}	% of initial Ca^{+2}	Mg^{+2}	% of initial Mg^{+2}	Na^{+}	% of initial Na^{+}	Cl^{-}	% of initial Cl^{-}
Sand	COL1PV1	12/12/99	1.35	3956		880		4644		15120	
	COL1PV2	12/20/99	1.81	561		181		1611		3421	
	COL1PV3	12/27/99	1.70	22		5		417		104	
	COL1PV4	12/28/99	2.41	14		5		395		24	
	COL1PV5	01/11/00	2.21	15		4		358		4	
	COL1PV6	01/19/00	2.60	18		55		437		3	
	COL1PV7	02/01/00	1.93	14		6		326		4	
	Total Estimated Mass Leached			64405		15903		114627		261514	
NaCl	COL2PV1	12/12/99	1.50	11610		1950		174000	25.72	264000	19.08
	COL2PV2	12/20/99	1.86	*4650*		*830*		161820	23.92	243660	17.61
	COL2PV3	12/27/99	1.72	2666		602		118852	17.57	230480	16.65
	COL2PV4	12/28/99	2.13	1082		298		95211	14.07	71000	5.13
	COL2PV5	01/11/00	2.32	288		65		76560	11.31	111824	8.08
	COL2PV6	01/19/00	2.07	35		17		3002	0.44	2712	0.20
	COL2PV7	02/01/00	2.52	58		91		1366	0.20	396	0.03
	Total Estimated Mass Leached			20389		3852		630810	72.67	924071	64.17
	Initial Mass Added							868000	100.00	1440000	100.00
	Initial Mass Remaining							237190	27.33	515929	35.83
Inhibited NaCl (NaCl with Iceban)	COL3PV1	12/12/99	1.52	4955		933		130264	23.20	273600	31.15
	COL3PV2	12/20/99	1.73	*3070*		*690*		167637	29.85	266420	30.33
	COL3PV3	12/27/99	1.60	4965		1216		149920	26.70	214400	24.41
	COL3PV4	12/28/99	2.22	1388		608		143412	25.54	85500	9.73
	COL3PV5	01/11/00	2.19	107		103		69423	12.36	96579	10.99
	COL3PV6	01/19/00	2.45	22		7		15264	2.72	16048	1.83
	COL3PV7	02/01/00	1.67	7		2		1553	0.28	254	0.03
	Total Estimated Mass Leached			14514		3559		677473	78.05	952800	66.17
	Initial Mass Added							868000	100.00	1440000	100.00
	Initial Mass Remaining							190527	21.95	487200	33.83
C-50	COL4PV1	12/12/99	1.51	39411	22.57	2597		11657		77010	18.27
	COL4PV2	12/20/99	1.63	37490	15.38	*1240*		10970		64059	15.19
	COL4PV3	12/30/99	1.81	19548	8.02	1376		7584		45612	10.82
	COL4PV4	12/31/99	2.26	2802	1.15	314		2328		4280	1.02
	COL4PV5	01/14/00	2.28	1222	0.50	162		1386		4423	1.05
	COL4PV6	01/19/00	2.41	603	0.25	96		1104		2039	0.48
	COL4PV7	02/01/00	1.96	319	0.13	51		343		298	0.07
	Total Estimated Mass Leached			101395	57.29	5836		35372		197721	42.89
	Initial Mass Added			177000	100.00					461000	100.00
	Initial Mass Remaining			75605	42.71					263279	57.11
Calban	COL5PV1	12/12/99	1.66	101094	31.42	2623		10109		177620	31.95
	COL5PV2	12/20/99	1.65	36465	11.34	*990*		4356		69300	12.46
	COL5PV3	12/30/99	1.90	26980	8.39	741		3154		51490	9.26
	COL5PV4	12/31/99	2.23	4326	1.34	132		1004		4310	0.78
	COL5PV5	01/14/00	2.24	226	0.07	9		235		282	0.05
	COL5PV6	01/19/00	2.49	157	0.05	5		192		192	0.03
	COL5PV7	02/01/00	2.37	107	0.03	2		128		31	0.01
	Total Estimated Mass Leached			169355	64.39	4602		19178		303226	49.22
	Initial Mass Added			263000	100.00					616000	100.00
	Initial Mass Remaining			93645	35.61					312774	50.78
M-50	COL6PV1	12/12/99	1.51	8632		17365	7.14	11401		69460	10.04
	COL6PV2	12/20/99	1.99	*3770*		12776	5.26	*5800*		44576	6.44
	COL6PV3	12/27/99	1.56	3635		9469	3.90	6302		32448	4.69
	COL6PV4	12/28/99	1.95	3179		8639	3.55	6903		16600	2.40
	COL6PV5	01/13/00	2.21	234		1445	0.59	1569		4310	0.62
	COL6PV6	01/19/00	2.54	109		437	0.18	549		518	0.07
	COL6PV7	02/01/00	2.13	104		243	0.10	181		277	0.04
	Total Estimated Mass Leached			19663		50374	66.28	32705		168189	39.20
	Initial Mass Added					76000	100.00			429000	100.00
	Initial Mass Remaining					25626	33.72			260811	60.80
FreezeGard	COL7PV1	12/09/99	1.42	11133		58220	11.91	10607		257020	18.47
	COL7PV2	12/20/99	1.96	*4190*		27440	5.61	6448		107996	7.76
	COL7PV3	12/23/99	1.36	721		3849	0.79	1224		13396	0.96
	COL7PV4	12/24/99	2.83	158		846	0.17	804		1070	0.08
	COL7PV5	01/13/00	2.20	48		79	0.02	202		130	0.01
	COL7PV6	01/19/00	2.05	82		62	0.01	172		131	0.00
	COL7PV7	02/01/00	2.33	14		61	0.01	161		28	0.00
	Total Estimated Mass Leached			16260		90556	67.08	19619		379671	63.38
	Initial Mass Added					135000	100.00			599000	100.00
	Initial Mass Remaining					44444	32.92			219329	36.62

Table 9
Column Leachate Ionic Species Mass Balance Estimates Summary
MDT Anti-Skid Material Research Project
Column Leach Study
(All mass values in milligrams)

Column ID	Total Leach Volume (ml)		Ca^{+2}	% of Initial Ca^{+2}	Mg^{+2}	% of Initial Mg^{+2}	Na^{+}	% of Initial Na^{+}	Cl^{-}	% of Initial Cl^{-}
Sand	14000	Total Estimated Mass Leached	64,405		15,903		114,627		261,514	
NaCl	14110	Total Estimated Mass Leached	20,389		3,852		630,810	72.67	924,071	64.17
		Initial Mass Added					868,000	100.00	1,440,000	100.00
		Initial Mass Remaining					237,190	27.33	515,929	35.83
Inhibited NaCl (NaCl with Iceban)	13365	Total Estimated Mass Leached	14,514		3,559		677,473	78.05	952,800	66.17
		Initial Mass Added					868,000	100.00	1,440,000	100.00
		Initial Mass Remaining					190,527	21.95	487,200	33.83
C-50	13860	Total Estimated Mass Leached	101,395	57.29	5,836		35,372		197,721	42.89
		Initial Mass Added	177,000	100.00					461,000	100.00
		Initial Mass Remaining	75,605	42.71					263,279	57.11
Calban	14325	Total Estimated Mass Leached	169,355	64.39	4,502		19,178		303,226	49.23
		Initial Mass Added	263,000	100.00					616,000	100.00
		Initial Mass Remaining	93,645	35.61					312,774	50.78
M-50	13875	Total Estimated Mass Leached	19,663		50,374	66.28	32,705		168,189	39.20
		Initial Mass Added			76,000	100.00			429,000	100.00
		Initial Mass Remaining			25,626	33.72			260,811	60.80
FreezeGard	14140	Total Estimated Mass Leached	16,250		90,556	67.08	19,619		379,671	63.38
		Initial Mass Added			135,000	100.00			599,000	100.00
		Initial Mass Remaining			44,444	32.92			219,329	36.62

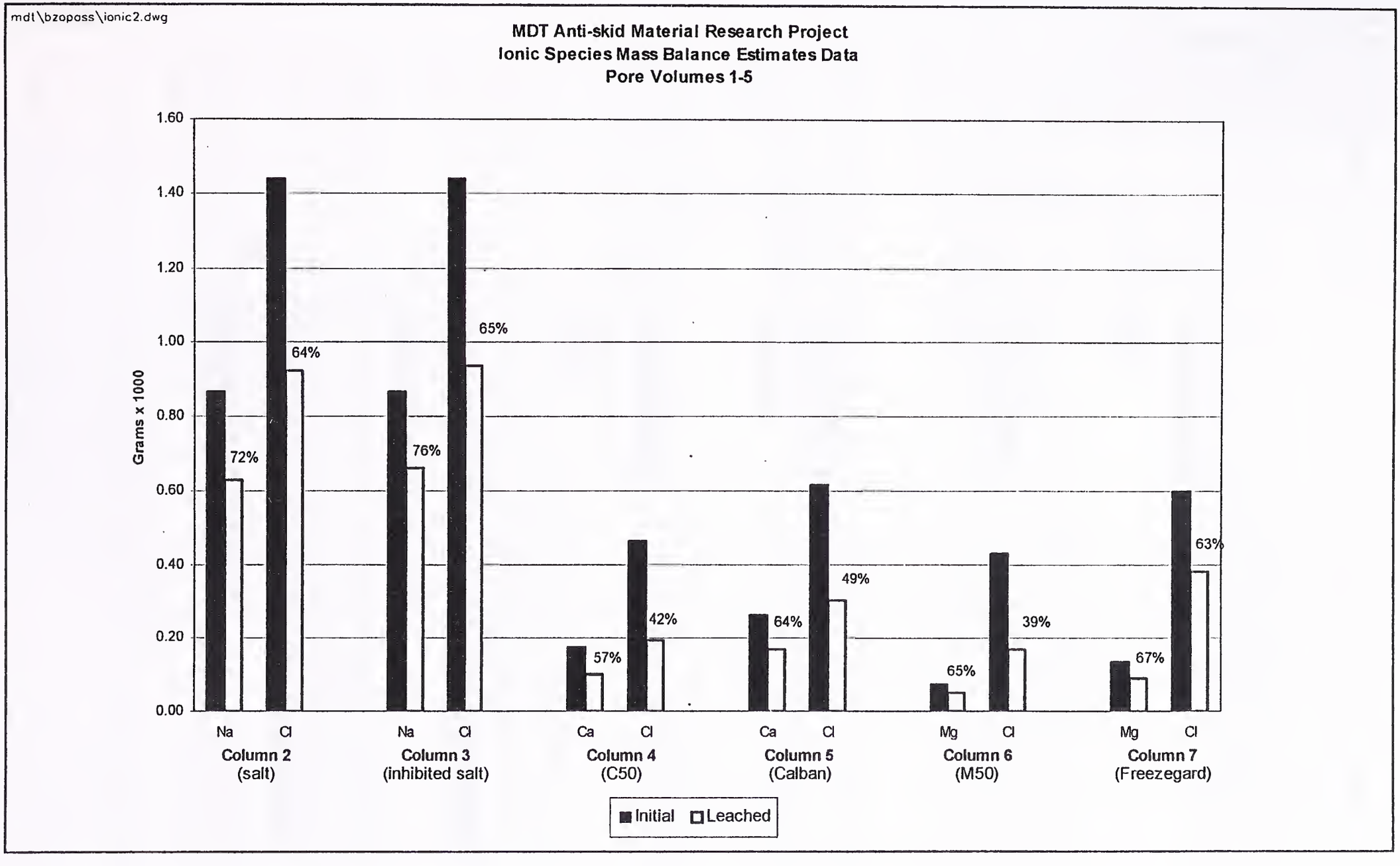
mdl\bzopass\ionic1.dwg



Ionic Species Mass Balance Estimates Data
Montana Department of Transportation
Anti-Skid Material Research Project
Bozeman Pass, Montana
FIGURE 7

MAXIM TECHNOLOGIES INC® 9911852

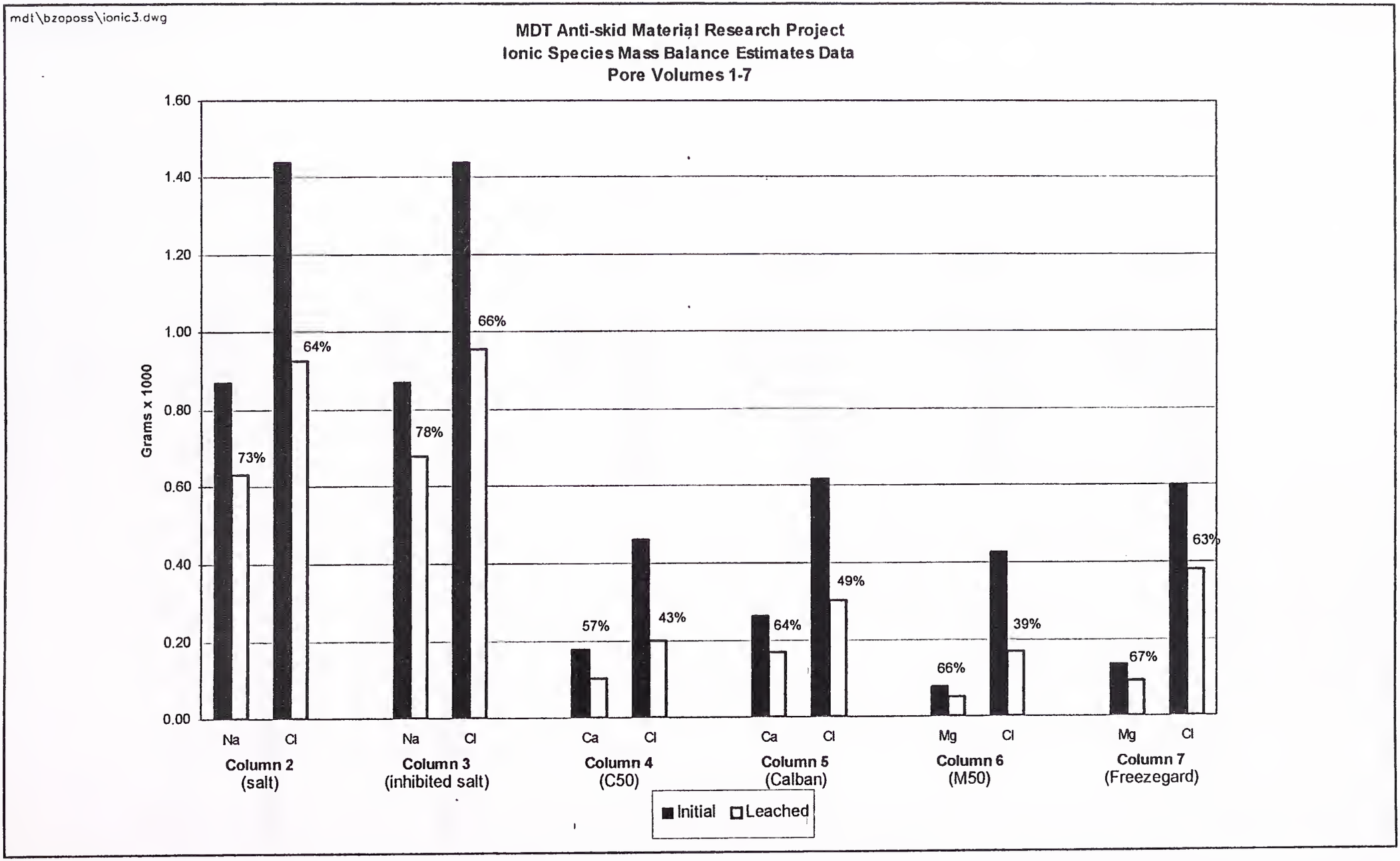
mdt\bzopass\ionic2.dwg



Ionic Species Mass Balance Estimates Data
Montana Department of Transportation
Anti-Skid Material Research Project
Bozeman Pass, Montana
FIGURE 8

MAXIM TECHNOLOGIES INC. 9911852

mdt\bzoposs\ionic3.dwg



Ionic Species Mass Balance Estimates Data
Montana Department of Transportation
Anti-Skid Material Research Project
Bozeman Pass, Montana
FIGURE 9

Following compilation of the column leach data, these data were reviewed and evaluated for identifiable trends. First, the raw laboratory data compiled in Table 8, along with the corresponding analyte concentration versus pore volume graphs in Appendix D were reviewed, followed by a review and evaluation of the estimated mass values in Table 9 and Figures 7 through 9. Key observations from these data reviews are discussed below.

3.1.7 Raw Laboratory Data

Review of the data in Table 6 and the corresponding graphs in Appendix D indicates that for all columns, the most significant leaching occurs within the first three to four pore volumes. Specifically, in most cases, concentrations of ionic species decreased several orders of magnitude by the fifth pore volume. Notable exceptions to this observation are the two columns amended with salt in which there appears to be a more steady leaching of both sodium and chloride relative to the other columns. Leach volume data indicate that all columns leached approximately equal volumes of water, i.e., approximately 14 liters, through PV-7.

Bicarbonate data indicate either steady or generally increasing concentrations throughout all seven pore volumes for the untreated sand as well as for columns with less amounts of Ice Ban™. However, for the two columns with 50% Ice Ban™ added (C-50 and M-50), initially high carbonate species concentrations were observed followed by a steady decrease. This is likely due to the presence of carbonate species in Ice Ban™.

While sulfate was not a component of any of the amendments, it appears to be an impurity in several. Specifically, all amended columns show elevated sulfate concentrations relative to the untreated column, with the C-50 and M-50 columns showing the highest sulfate. While some of the sulfate is clearly from the salts, it is also known to be present in Ice Ban™.

Chemical oxygen demand (COD), which is essentially the amount of oxygen required for abiotic oxidation of organic matter, tends to increase with an increasing quantity of Ice Ban™. Given that Ice Ban™ is predominantly organic, this stands to reason. For biochemical oxygen demand (BOD), which is the amount of oxygen required for biological decomposition of organic matter, the only columns showing any appreciable BOD are those containing Ice Ban™, which for the same reason as for COD, stands to reason.

Review of pH values indicates a general increase in leachate pH with time. This is likely the result of the continued presence of carbonate species coupled with progressively decreasing calcium concentrations. Even with the general increase in pH; however, pH values are all relatively neutral, ranging generally between 6 and 9.

Total dissolved solid (TDS) concentrations generally parallel NaCl, $CaCl_2$ and $MgCl_2$ concentrations, although comparison of the NaCl and NaCl with Ice Ban™ data suggests the presence of Ice Ban™ may partially diminish TDS concentrations.

Total organic carbon (TOC) data indicate some organic carbon is present in the untreated sand. Otherwise, TOC data generally parallel Ice Ban™ concentrations, which is to be expected.

Nitrate and nitrite data indicate minimal concentrations in untreated sand, but increase with addition of Ice Ban™. Because Ice Ban™ is known to contain small concentrations of nitrogen, this is not unexpected. Likewise, phosphorus concentrations show the same general trend, and Ice Ban™ is also known to contain phosphorus.

3.1.8 Mass Estimate Data

From a review of data in Table 10 and the corresponding graphs in Figures 7 through 9, a number of observations were made regarding the percentages of ionic species leached through PV-7. Treatment with all six of the additives resulted in the addition of chloride (anions). Observations of chloride leaching include the following:

- Columns treated with Salt, Salt amended with Ice Ban™ (Salt Ban), and FreezGard lost the greatest percentage of chloride anions through PV-7. Percentage losses of chloride in these three treatments were very similar ranging from 63.38% to 66.17%.

- The Cal Ban column leached approximately 50% of its initial chloride, and the C-50 and M-50 columns leached the least, approximately 40%.

- The addition of Ice Ban™ to the various treatments did not notably reduce chloride loss during leaching.

Observations of cation leaching include the following:

- The Salt and Salt Ban columns leached similar quantities of added sodium (approximately 75%).

- The C-50 column appears to have less propensity to leach calcium than does the Cal Ban, with the percentages of leached calcium in these two columns at 57% and 64%, respectively.

- The two columns containing magnesium (M-50 and FreezGard) leached approximately 66% of the initial magnesium.

Collectively, the data through PV-7 suggest that the NaCl based additives have a greater propensity to leach cations than the calcium and magnesium based additives (i.e., sodium versus calcium and magnesium). However, all columns have leached well over half of their initial cations through PV-7, and most of this leached within the first four pore volumes. Concerning chloride, again the NaCl additives generally appear to have the greatest propensity to leach.

The average percent cations and anions leached for each anti-freezing agent was used as an index for overall leaching performance, as shown in Table 10. These averages indicate that Salt Ban has the greatest propensity to leach ionic species, followed in order by Salt, FreezGard, Cal Ban, M-50, and C-50.

TABLE 10
Percent Cations and Anions Leached from Columns through Pore Volume 7
MDT Anti-Skid Material Research Project

Anti-Freezing Agent	Percent of Primary Cation Leached	Percent of Chloride Leached	Average Percent Primary Cation plus Chloride Leached
Salt	72.67	64.17	68.42
Salt Ban	78.05	66.17	72.11
C-50	57.29	42.89	50.09
Cal Ban	64.39	49.23	56.81
M-50	66.28	39.20	52.74
FreezGard	67.08	63.38	65.23

3.2 Bozeman Pass Stockpile Tests

The results of the field studies that were conducted at the Bozeman Pass site are presented in this section. The objectives of the field study were to evaluate the effectiveness of an asphalt stockpile cover on leachate control, and evaluate workability of sand amended with various anti-freezing agents under sub-zero (Fahrenheit) conditions.

An integral part of the field study was the monitoring of weather conditions at the Bozeman Pass site. As previously discussed, mild weather conditions during the winter of 1999-2000 prevented the workability study from proceeding because stockpiles did not freeze. Therefore, the field study was continued during the winter of 2000-2001.

3.2.1 Weather Monitoring

Precipitation and temperature data measured at the RWIS at the Bozeman Pass site are summarized below in Table 11. Daily precipitation data from these two periods are shown graphically on Figure 10, and mean daily temperature data are shown on Figure 11. These data indicate 4.8 more inches (12.2 cm) of precipitation fell during the winter (November through March) of 2000-2001 than during the winter of 1999-2000, and the mean daily temperature was 6.7 F° (3.2 C°) colder during the winter of 2000-2001 than during the winter of 1999-2000.

3.2.2 Stockpile Leach Collection System

For the evaluation of the asphalt cover on the leach test stockpiles, the volume of water in the leachate collection tanks was monitored periodically throughout the period from November 1999 through April 2000. This monitoring involved measuring the depth of leachate water in the two tanks and calculating volumes based on the tank diameter of 5 feet. The results of the measurements and corresponding calculated water volumes (in gallons) are listed in Table 12.

TABLE 11 Precipitation and Temperature Summary MDT Anti-Skid Material Research Project		
	2000-2001	**1999-2000**
Total Precipitation, inches (cm)	12.5 (31.8)	7.7 (19.5)
Mean Daily Temperature, ° F (° C)	25.6 (-3.6)	32.3 (0.2)
Coldest Mean Daily Temperature Recorded, ° F (° C)	-6.5 (-21.4)	9.7 (-12.4)
Number of Days with Mean Daily Temperatures below 32° F (0° C)	138	88
Number of Days with Mean Daily Temperatures below 0° F (-17.8° C)	5	0

TABLE 12
1999-2000 Leach Stockpile Collection Tanks Water Levels and Volumes
MDT Anti-Skid Material Research Site

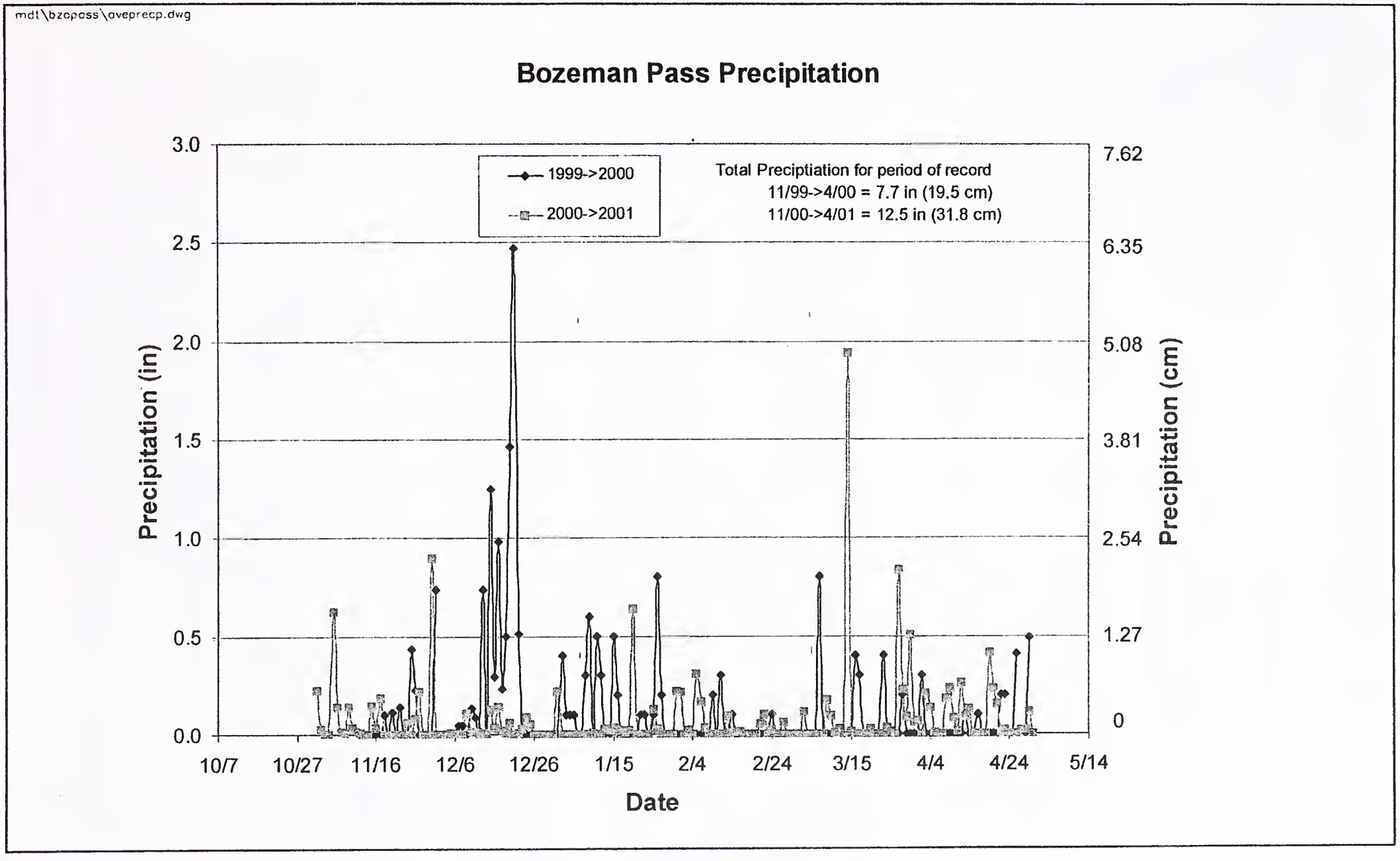
Date	Water Depth (inches)		Water Volume (gallons)	
	Uncovered Leach Pile	Covered Leach Pile	Uncovered Leach Pile	Covered Leach Pile
1/10/00	0.00	2.50	0.00	30.58
1/12/00	0.00	2.50	0.00	30.58
1/1900	0.00	2.50	0.00	30.58
1/31/00	0.00	2.50	0.00	30.58
2/8/00	0.50	2.50	6.12	30.58
2/25/00	3.25	8.75	39.76	107.40
3/1/00	3.34	13.14	40.86	160.74
3/24/00	6.34	21.5	77.56	263.01
4/6/00	9.5	29.5	116.21	360.87
4/27/00	11.5	35.5	140.68	434.27

Notes: Heat tape activated on 12/13/99.
Test initiated during November 1999.
Test re-initiated during November 2000.

By April 27, 2000, the uncovered stockpile leached a total of approximately 141 gallons (533.7 L) of leachate, while the asphalt covered stockpile leached approximately 434 gallons (1,642.9 L), for a ratio of approximately three-to-one. These results were the opposite of what were expected, and while the reasons were not known, Maxim and MDT investigated several possibilities.

One possible explanation for the observed results was that water was entering the covered stockpile from precipitation water trapped inside the small berm constructed around the base of the stockpiles to prevent

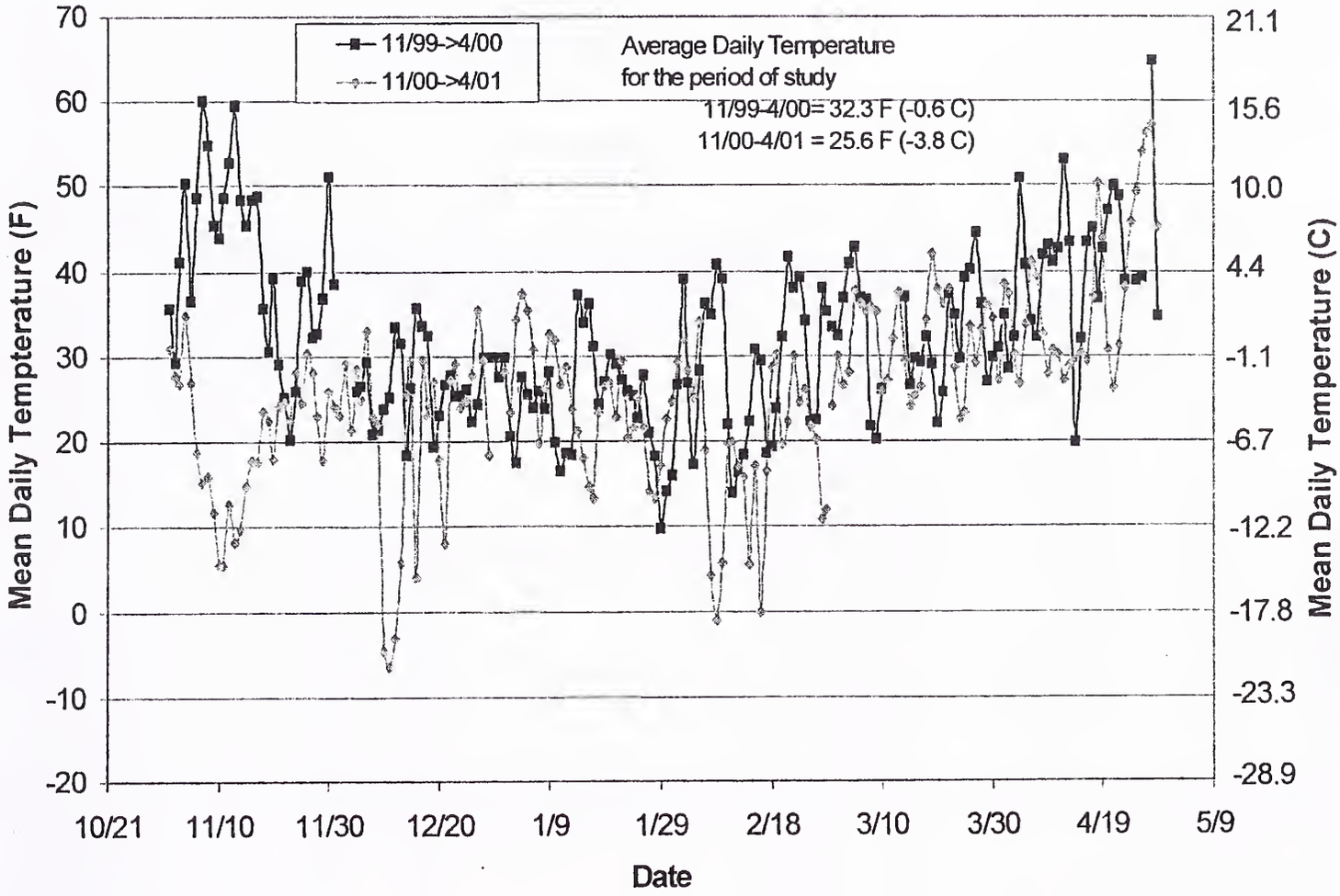
mdt\bzopass\oveprecp.dwg



Bozeman Pass Daily Precipitation Totals
Montana Department of Transportation
Anti-Skid Material Research Project
Bozeman Pass
FIGURE 10

MAXIM 9911852.100

mdl\bzapass\avetemp.dwg



Bozeman Pass Daily Average Temperatures
Montana Department of Transportation
Anti-Skid Material Research Project
Bozeman Pass
FIGURE 11

MAXIM 9911852.100

run-on. To ensure that water in the covered stockpile leach tank was in fact precipitation water leaching through the pile and not water from an unknown source, a dye tracer test was conducted. Specifically, four 1-ounce bottles of Schilling® red food coloring were poured into snow accumulated at the base of the covered leach test stockpile and inside the small berm. By March 24, 2000 when Maxim personnel next visited the site, the water in the covered stockpile collection tank was distinctly red. This test indicated that precipitation runoff was contributing to the volume of water entering the collection tank.

In addition, Maxim personnel collected a water sample from the covered stockpile collection tank for analysis by NAL for the same sample parameters as used in the column studies. The laboratory analytical report is included in Appendix F, and indicates that the water had essentially the same composition as that from the salt column (Column No. 2), although the water in the leach tank did have a considerably higher BOD than did the corresponding laboratory column. The higher BOD concentration may be the result of the asphalt emulsion applied as cover material to this stockpile. The similarity in these analytical test results suggested that although precipitation runoff was likely entering the collection tank, its contribution to the total volume in the tank was likely not significant.

Once it was determined that the water in the collection tanks was predominantly derived from the stockpiles, additional alternative explanations were developed including possible problems with the water collection/conveyance system within the stockpiles. It was thought possible that the water conveyance system for the uncovered stockpile had been ruptured, resulting in high losses between the stockpile and the water collection tanks.

During the fall of 2000, Maxim and MDT personnel dismantled the two leach stockpiles to inspect the plumbing systems. While Maxim personnel did observe some breaches in the liner in the uncovered stockpile pad, there were also indications of a liner breach in the covered stockpile pad. However, because of damage to the liner and plumbing that occurred from heavy equipment during the dismantling process, Maxim personnel could make no firm conclusions.

Two new leach stockpiles were constructed in the fall of 2000, and one was again covered with asphalt. Unlike the two previous stockpiles, these stockpiles were not constructed with berms at their bases. Instead, the stockpiles were contoured so that precipitation runoff reaching the base of the stockpiles would not collect within the leach collection systems. These stockpiles remained in place through the winter of 2000-2001.

Although the available precipitation data indicates that precipitation during the 2000-2001 study period was greater than during the 1999-2000 study period, the volume of water leached through the two stockpiles was only a fraction of what leached the previous winter. Specifically, Maxim personnel visited the site several times during the winter of 2000-2001 and found no measurable quantity of water in the leachate collection tanks. On April 9, 2001, measurements indicated that the uncovered stockpile collection tank contained approximately 43 gallons (162.8 L), while the covered stockpile collection tank contained approximately 98 gallons (371.0 L). However, during this inspection, it was discovered that the pipe leading from the covered leach pile to its collection tank had broken at some point through the winter under the weight of drifting snow. The pipe from the uncovered tank was in good condition. The differences in leachate volumes collected in the tanks, even with consideration of possible losses due to the covered stockpile pipe failure, indicates the covered stockpile again leached more fluid than did the uncovered stockpile. The lower total leachate volumes observed during the winter of 2000-2001

compared to the winter of 1999-2000, may be due to the elimination of the berms at the bases of the stockpiles built in October 2000.

In contrast to initial expectations, the leachate collection results from both 1999-2000 and 2000-2001 indicate that the asphalt-covered stockpile produced more leachate than the uncovered stockpile. Possible explanations for what appeared to be anomalous test results include the following:

- Repeated occurrence of a plumbing failure.

- Higher internal temperature in the covered versus the uncovered leach test stockpile. To evaluate this possibility, Maxim constructed and inserted a thermocouple into each of the two leach test stockpiles such that the end of each rod was located in the approximate geometric center of each pile. Voltage measurements were made on March 1 and on April 6, 2000, and in both cases voltage measurements were identical, indicating no temperature differential between the two stockpiles.

- Application of the asphalt cover may have altered the solar energy budget between the two piles. If the surface temperature of the asphalt cover is greater than the surface temperature of the uncovered pile, accumulated snow may tend to melt more readily from the asphalt surface. This water would then accumulate at the base of the pile and would then enter the leachate collection system. Conversely, snow that accumulated on the cooler uncovered pile may be removed by wind.

- The possibility that application of the asphalt cover reduces potential evaporation of soil moisture in the covered stockpile but also allows identical amounts of precipitation to enter the two stockpiles.

Regardless of possible reasons, stockpile leach collection data acquired over two winters indicate that the covered leach stockpiles leach from approximately two to three times more fluid than the uncovered stockpiles. This conclusion is supported by review of soil moisture data associated with the workability study that is discussed in the following sections.

3.2.3 Workability Evaluation

Because of unusually warm weather during the winter of 1999/2000, sustained freezing did not occur in any of the workability test stockpiles. Consequently, no core samples were collected from any of the 12 workability stockpiles during the 1999-2000 field season.

Adequately cold temperatures were sustained during the winter of 2000-2001 for stockpiles to freeze. Three sampling events were conducted during the winter of 2000-2001. Results of these sampling events are tabulated in Table 13, and are summarized in Table 14. Specifically, for each face of each stockpile sampled during three sampling events, Table 14 lists the following:

- Maximum depth of the frost rind;

- Mean mass of sample collected;

- Mean percent of sample retained in a 3/8-inch sieve analysis; and,

- A general description of the material retained in the sieve (i.e., frozen sand versus moist sand clods versus gravel).

From the data in Table 14 a series of key findings were made as discussed below.

- In general, the north faces of the stockpiles were more susceptible to freezing than were the south faces, and in many cases the south face was not frozen at all.

- In general, asphalt covered stockpiles were more susceptible to freezing than were the uncovered stockpiles which possibly resulted from slightly higher soil moisture content in the covered stockpiles compared to the uncovered stockpiles.

- Of the six different anti-freezing agents, the deepest frost rinds were observed in the covered stockpiles amended with Cal Ban and FreezGard. Uncovered stockpiles amended with C-50, M-50 and Salt showed moderate frost rinds. No frozen rind was observed in the uncovered stockpile amended with Salt Ban.

- Of the six uncovered stockpiles, the highest retention of frozen sand in the sieve analyses was observed for FreezGard followed by C-50 and Cal Ban. Frozen sand retention was negligible for Salt, Salt Ban, and M-50.

- No freezing was observed in the two new salt stockpiles constructed in the fall of 2000.

Table 13

Stockpile Workability Results

MDT Anti-Skid Material Research Project

Stockpile	Composition	Face	Date	Frost Thickness			Sample Analyses					Comments
				Frozen Interval (Inches)	Partially Frozen Interval (Inches)	Interval of Sample Collection	Total Mass of Sample (g)	Mass Passing 3/8 Inch Sieve (g)	Percent Retained	Composition of Retained Material	Soil Moisture (%)	
1	C-50 Covered	N	12/14/01	0-12	12-13	12-16	1410	1240	12	100% frozen sand	10.9	
			1/31/2001	0-10	10-10	12-16	340	318	7		14.9	
			2/28/2001	0-22	10-10	22-28	885	748	15	90% frozen sand, 10% gravel	7.5	Very hard drilling
						Mean	878	769	11		11	
		S	12/14/01	0-18	16-20	20-24	1367	1329	3		6.8	
			1/31/2001	0-0	0-0	14-20	204	159	22	100% frozen sand	5.9	
			2/28/2001	4-9	0	16-24	318	295	7	50% frozen sand, 50% gravel	5.9	
						Mean	630	594	11		8	
2	C-50 Uncovered	N	12/14/01	0	6-12	13-17	808	785	3	50% frozen sand, 50% gravel	6.1	
			1/31/2001	0	7-16	16-22	590	567	4	80% frozen sand, 20% gravel	6.3	Moderately hard drilling
			2/28/2001	1-8	8-13	13-24	499	454	9	80% frozen sand, 20% gravel	5.9	
						Mean	632	602	5		6	
		S	12/14/01	6.5-18	0-0	16-22	990	972	2	100% gravel	7.3	
			1/31/2001	0-0	0-0	16-22	318	318	0	100% gravel	5.7	Slight resistance from 5 to 6 inches
			2/28/2001	0-0	0-0	16-24	476	454	5	100% gravel	5.1	
						Mean	595	581	2		6	
3	CalBan Covered	N	12/14/01	2-14.5	0-0	15-18	1031	979	5	33% frozen sand, 67% gravel & asphalt	5.4	
			1/31/2001	0-30	0-0	30-36	1406	1157	18	95% frozen sand, 5% gravel	8.7	Hard drilling
			2/28/2001	0-23	0-0	23-30	1043	953	9	95% frozen sand, 5% gravel	6.6	Very hard drilling
						Mean	1160	1029	10		7	
		S	12/14/01	3-17	0-0	17-20	1384	1341	3	33% frozen sand, 67% gravel & asphalt	6.6	Very hard drilling
			1/31/2001	0-17	0-0	17-22	590	544	8	40% frozen sand, 60% gravel	7.2	
			2/28/2001	4-10	0-4	16-24	386	363	6	100% gravel	5.9	Moderately hard drilling
						Mean	786	749	8		7	
4	CalBan Uncovered	N	12/14/01	4-16	0	18-22	1425	1408	1	100% gravel	6.1	Hard drilling
			1/31/2001	2-17	0	17-22	635	612	4	100% gravel	5.6	Progressively harder drilling with depth
			2/28/2001	6-18	0-6	18-26	1338	1270	5	10% frozen sand, 90% gravel	5.8	Hard drilling
						Mean	1133	1097	3		8	
		S	12/14/01	0	0	10-16	644	835	1	100% gravel	5.4	
			1/31/2001	0	0	17-22	204	204	0	No material retained	5.4	
			2/28/2001	0	0	16-24	204	159	22	80% moist sand clods, 20% gravel	4.3	Clods not frozen
						Mean	351	333	8		5	
5	SaltBan Covered	N	12/14/01	0-8	8-12	16-21	588	534	9	100% frozen sand	5.1	
			1/31/2001	0-14	0	14-20	454	431	5	85% frozen sand, 15% gravel	6.0	Very hard drilling
			2/28/2001	1-13	0-1	16-24	499	476	5	95% frozen sand, 5% gravel	5.1	Hard drilling
						Mean	514	480	6		5	
		S	12/14/01	0	0	17-20	777	764	2	100% gravel	4.9	
			1/31/2001	0	0	18-24	181	181	0	No material retained	5.9	
			2/28/2001	0	0	16-24	181	181	0	No material retained	5.1	
						Mean	380	376	1		5	
6	SaltBan Uncovered	N	12/14/01	0	0-1	14-18	446	432	3	100% gravel	4.9	
			1/31/2001	0	0-7	15-22	181	159	13	100% gravel	5.0	
			2/28/2001	0	0	16-24	249	249	0	No material retained	5.0	
						Mean	292	280	5		5	
		S	12/14/01	0	0	19-22	537	529	1	100% gravel	4.6	
			1/31/2001	0	0	14-20	204	181	11	100% gravel	5.0	
			2/28/2001	0	0	16-24	204	159	22	100% high moisture sand clods	4.6	
						Mean	315	290	12		5	

Table 13
Stockpile Workability Results
MDT Anti-Skid Material Research Project

Stockpile	Composition	Face	Date	Frost Thickness			Sample Analyses					Comments
				Frozen Interval (Inches)	Partially Frozen Interval (Inches)	Interval of Sample Collection	Total Mass of Sample (g)	Mass Passing 3/8 Inch Sieve (g)	Percent Retained	Composition of Retained Material	Soil Moisture (%)	
7	Salt Covered	N	12/14/01	0-7	7-9	9-14	342	308	10	75% frozen sand, 25% gravel	7.1	Hard drilling from 0 to 7 inches
			1/31/2001	0-14	0	14-22	544	476	13	80% frozen sand, 20% gravel	6.8	Very hard drilling
			2/28/2001	0-8	0	16-24	363	340	6	100% gravel	4.9	Moderately hard drilling
						Mean	416	375	10		6	
		S	12/14/01	0	0	15-20	431	408	5	100% gravel	5.0	
			1/31/2001	0	0	16-24	159	159	0	No material retained	4.2	
			2/28/2001	0	0	16-24	318	318	0	No material retained	4.8	
						Mean	302	295	2		5	
8	Salt Uncovered	N	12/15/00	0-6	0	7-10	204	184	10	90% frozen sand, 10% gravel	5.8	Very hard drilling
			1/31/2001	0	0-6	14-22	159	136	14	25% frozen sand, 75% gravel	4.7	
			2/28/2001	0-8	0	16-24	181	159	13	100% gravel	5.1	Moderately hard drilling
						Mean	181	160	12		5	
		S	12/15/00	0	0	12-15	338	338	0	No material retained	4.6	
			1/31/2001	0	0	15-22	340	318	7	100% gravel	4.4	
			2/28/2001	0	0	16-24	181	181	0	No material retained	4.3	
						Mean	287	279	2		4	
9	FreezGard Covered	N	12/15/00	0-14	14-16	17-20	816	744	9	85% frozen sand, 15% gravel	5.7	Very hard drilling
			1/31/2001	0-18	0	18-24	658	590	10	95% frozen sand, 5% gravel	6.3	Hard drilling
			2/28/2001	0-23	0	23-32	794	748	6	80% frozen sand, 20% gravel	5.9	Very hard drilling to 20 inches
						Mean	756	694	8		6	
		S	12/15/00	0-17	0	17-20	1170	1106	5	75% frozen sand, 25% gravel	6.5	Very hard drilling
			1/31/2001	0	0-5	13-18	204	204	0	No material retained	5.4	
			2/28/2001	0	0	18-26	227	227	0	No material retained	6.1	
						Mean	534	512	2		6	
10	FreezGard Uncovered	N	12/15/00	3-15	15-16	17-20	895	850	5	90% frozen sand, 10% gravel	6.0	
			1/31/2001	0-7	0	7-18	431	408	5	100% frozen sand	5.9	
			2/28/2001	1-13	0-1	13-24	590	567	4	70% frozen sand, 30% gravel	6.5	Hard drilling
						Mean	639	608	5		6	
		S	12/15/00	0	0	14-18	305	305	0	No material retained	5.4	
			1/31/2001	0	0	15-22	227	204	10	100% gravel	5.5	
			2/28/2001	0	0	16-24	227	227	0	No material retained	5.1	
						Meen	253	245	3		5	
11	M-50 Covered	N	12/14/01	0-19	19-24	24-27	1709	1830	5	75% frozen sand, 25% gravel	7.4	Very hard drilling from 9 to 19 inches
			1/31/2001	0-22	0	26-32	1315	1111	16	90% frozen sand, 10% gravel	6.6	Very hard drilling
			2/28/2001	0-26	0	26-34	930	907	2	90% frozen sand, 10% gravel	6.3	Extremely hard drilling. Very moist after 26 inches
						Mean	1318	1216	8		7	
		S	12/14/01	0-18	0	18-22	1268	1216	4	50% frozen sand, 50% gravel	6.4	Very hard drilling from 0 to 18 inches
			1/31/2001	0	0	14-22	204	204	0	No material retained	6.1	
			2/28/2001	0	5-7	16-24	431	408	5	100% gravel	6.0	
						Mean	634	609	3		6	
12	M-50 Uncovered	N	12/14/01	0	2.5-8	13-17	803	778	3	25% frozen sand, 75% gravel	5.8	Moderate drilling resistance
			1/31/2001	0	7-18	18-24	703	635	10	90% frozen sand, 10% gravel	6.5	One large frozen piece ~ 45 g
			2/28/2001	2-11	0-2	16-24	839	816	3	25% frozen sand, 75% gravel	5.9	Moderately hard drilling
						Mean	782	743	5			
		S	12/14/01	0	0	12-16	428	420	2	100% gravel	6.0	
			1/31/2001	0	0	16-22	408	386	6	80% frozen sand, 20% gravel	6.3	
			2/28/2001	0	0	14-24	431	408	5	100% gravel	5.8	
						Mean	422	405	4		6	

Table 13
Stockpile Workability Results
MDT Anti-Skid Material Research Project

Stockpile	Composition	Face	Date	Frost Thickness			Sample Analyses					Comments
				Frozen Interval (inches)	Partially Frozen Interval (inches)	Interval of Sample Collection	Total Mass of Sample (g)	Mass Passing 3/8 Inch Sieve (g)	Percent Retained	Composition of Retained Material	Soil Moisture (%)	
13	Salt Covered (2000)	N	12/15/00	0	0	16-20	787	751	5	100% gravel	8.0	Appears very wet
			1/31/2001	0	0	17-24	249	227	9	5% moist sand clods, 95% gravel	7.5	Slightly harder drilling from 11 inches, high moisture
			2/28/2001	0	0	16-24	318	295	7	100% moist sand clods	7.5	16 to 24 inch interval appears moist
						Mean	451	424	7		8	
		S	12/15/00	0	0	12-16	736	718	2	100% gravel	6.7	
			1/31/2001	0	0	16-24	318	295	7	15% moist sand clods, 85% gravel	6.9	
			2/28/2001	0	0	16-24	318	295	7	100% gravel	6.7	16 to 24 inch interval appears moist
						Mean	457	436	6		7	
14	Salt Uncovered (2000)	N	12/15/00	0	0	14-20	512	509	1	100% gravel	6.3	
			1/31/2001	0	0	16-24	227	181	20	100% gravel	6.4	
			2/28/2001	0	0	16-24	227	204	10	100% gravel	6.6	16 to 24 inch interval appears moist
						Mean	322	298	10		6	
		S	12/15/00	0	0	14-20	737	712	3	100% gravel	5.8	
			1/31/2001	0	0	17-24	204	181	11	100% gravel	6.5	
			2/28/2001	0	0	16-24	249	181	27	95% moist sand clods, 5% gravel	6.3	16 to 24 inch interval appears moist
						Mean	397	358	14		6	

TABLE 14
Stockpile Freezing and Workability Results Summary
MDT Anti-Skid Material Research Project

Composition	Face	Maximum Depth of Frost Rind (inches)	Mean Mass of Samples (grams)	Mean Percent Mass Retained 3/8-inch Sieve	General Composition of Mass Retained
C-50 Covered	North	22	878	11	Primarily frozen sand
	South	16	630	11	Primarily frozen sand
C-50 Uncovered	North	8	632	5	Primarily frozen sand
	South	16	595	2	Entirely gravel
Cal Ban Covered	North	30	1160	10	Primarily frozen sand
	South	17	786	6	Primarily gravel
Cal Ban Uncovered	North	18	1133	3	Primarily frozen sand
	South	0	351	8	Moist sand clods and gravel
Salt Ban Covered	North	14	514	6	Primarily frozen sand
	South	0	380	1	Entirely gravel
Salt Ban Uncovered	North	0	292	5	Entirely gravel
	South	0	315	12	Moist sand clods and gravel
Salt Covered	North	14	416	10	Frozen sand and gravel
	South	0	302	2	Entirely gravel
Salt Uncovered	North	8	181	12	Primarily gravel
	South	0	287	2	Entirely gravel
FreezGard Covered	North	23	756	8	Primarily frozen sand
	South	17	534	2	Primarily frozen sand
FreezGard Uncovered	North	15	639	5	Primarily frozen sand
	South	0	253	3	Entirely gravel
M-50 Covered	North	26	1318	8	Primarily frozen sand
	South	18	634	3	Primarily gravel
M-50 Uncovered	North	11	782	5	Primarily gravel
	South	0	422	4	Primarily gravel
Salt Covered (2000-2001)	North	0	451	7	Moist sand clods and gravel
	South	0	457	6	Primarily gravel
Salt Uncovered (2000-2001)	North	0	322	10	Entirely gravel
	South	0	397	14	Gravel and moist sand clods

4.0 SUMMARY AND CONCLUSIONS

The ASM Research Study evaluated six anti-freezing agents that included Salt, Salt Ban, Cal Ban, C-50, M-50, and FreezGard. The project was divided into a laboratory component that evaluated leaching and leachate quality, and a field test component that focused on stockpile freezing and related stockpile workability. In addition, the study also evaluated SS-1 asphalt emulsion as a stockpile cover material. Relatively warm and dry weather conditions atop the Bozeman Pass during the winter of 1999-2000 resulted in an extension of the project through the winter of 2000-2001. Lower temperatures and higher precipitation during the winter of 2000-2001 allowed completion of the field study. A summary of the findings of the laboratory and field studies, and conclusions drawn from those findings is provided in the following discussion.

4.1 Leach Extraction

Maxim conducted bench-scale column tests to address MDT's concerns regarding loss of anti-freezing agents from stockpiles as a result of precipitation on those piles and subsequent leaching. Loss rate calculations were based on the measurement and loss of primary ionic species comprising each of the six agents (common anion being chloride, and cations being sodium, calcium, and magnesium). Findings of the column tests through seven pore volumes of leaching indicated the following:

- Salt and Salt Ban exhibited the greatest losses of both anions (64.17% and 66.17%, respectively), and cations (72.67% and 78.05%, respectively).

- FreezGard Zero, a magnesium chloride based anti-freezing agent, closely followed Salt and Salt Ban in anion (63.38%) and cation (67.08%) losses.

- C-50, Cal Ban, and M-50 exhibited similar but lower anion (39.20% to 49.23%) and cation (57.29% to 66.28%) losses than the aforementioned.

- Overall, column test data suggest that the majority of leaching will occur within the first four pore volumes, regardless of the anti-freezing agent.

4.2 Workability

The evaluation of stockpile workability included both the measurement of outer frost rinds, and sieve analysis of samples retrieved from the interiors of the stockpiles. Based on these two measures, we have drawn the following conclusions:

- Frost rind measurements indicate that Salt Ban is the most effective agent at preventing freezing of stockpile outer surfaces followed in order by Salt, FreezGard, M-50, C-50, and Cal Ban.

- Sieve analysis results indicated that Salt is the most effective agent at preventing freezing within the interiors of the stockpiles followed in order by Salt Ban, M-50, Cal Ban, FreezGard, and C-50.

As an index to ranking workability, the average frost rind in samples collected from the north and south faces of both covered and uncovered stockpiles were calculated for each of the six anti-freezing agents. These average depths, listed in Table 15, indicate that Salt Ban is the most effective at preventing freezing of stockpile outer surfaces followed in order by Salt, FreezGard, M-50, C-50 and Cal Ban. That the two stockpiles constructed in the fall of 2000 did not freeze at all suggests that weathering increases the propensity of a given stockpile to freeze.

Estimates of percent mass of frozen sand in the interiors of stockpiles also contributed to the workability evaluation. Specifically, the total average percent mass of material identified as primarily frozen sand retained in a 3/8-inch sieve was calculated for each of the six anti-freezing agents (Table 15). Based on these calculations, Salt has the greatest ability to prevent the interiors of stockpiles from freezing, followed in order by Salt Ban, M-50, Cal Ban, FreezGard and C-50.

TABLE 15
Average Anti-Freezing and Workability Indices
MDT Anti-Skid Material Research Project

Anti-Freezing Agent	Average Maximum Depth of Frost Rind (inches)	Total Average Percent Mass of Primarily Frozen Sand Retained in a 3/8-inch Sieve
C-50	15.5	27
Cal Ban	16.25	13
Salt Ban	3.5	6
Salt	5.5	0
FreezGard	8.5	15
M-50	13.75	8

4.3 SS-1 Cover Evaluation

For reasons presently unclear, stockpiles covered with asphalt appear to have a greater tendency for loss of anti-freezing additives as a result of leaching than uncovered stockpiles. During the two winters of the study, covered leach test stockpiles leached from two to three times the volume of water than the uncovered stockpiles. Various tests conducted, such as addition of red dye to snow on the outside of the covered stockpile and chemical analysis of water in the collection tanks, indicate that the majority of the water in the collection tanks resulted from leaching through the stockpiles. No construction or plumbing flaws were discovered when the two initial leach stockpiles were dismantled in the fall of 2000 prior to constructing two more stockpiles. Regardless of possible reasons, the results of the study indicate that the use of SS-1 to cover stockpiles is ineffective at preventing leaching.

The effectiveness of SS-1 in preventing stockpiles from freezing was evaluated with cooperative weather conditions during the winter of 2000-2001. Comparison of coring results of identically amended stockpile pairs, one uncovered and the other covered with SS-1, indicated that SS-1 covered stockpiles were more susceptible to freezing. This increased susceptibility may result from higher moisture content in the covered piles.

4.4 Overall Rating

In summary, Maxim rated or ranked the six anti-freezing agents (Salt, Salt Ban, C-50, Cal Ban, M-50, and FreezGard) using the results of the three primary components of the evaluation: leaching, frost rind, and interior freezing measurements and calculations. These rankings are summarized in Table 16. Based on total scores, lowest being best, Salt, Salt Ban, and M-50 appear to be the most desirable anti-freezing agents for use as additives in road sand stockpiles.

TABLE 16
Anti-Freezing Agent Rankings
MDT Anti-Skid Material Research Project

Anti-Freezing Agent	Ability to Minimize Leaching	Ability to Prevent Frost Rind	Ability to Prevent Stockpile Interior Freezing	Total Score
Salt	5	2	1	8
Salt Ban	6	1	2	9
C-50	1	5	6	12
Cal Ban	3	6	4	13
M-50	2	4	3	9
FreezGard	4	3	5	12

Note: Ranking: 1 = most desirable, and 6 = least desirable.

5.0 GLOSSARY

anti-freezing agent – chemical substance that when mixed with road sand lowers the freezing point of moisture in that sand, typically a chloride-based substance (e.g., salt).

anti-skid material – material, primarily road sand, spread on ice covered highways to increase traction, and prevent vehicle skidding.

biochemical oxygen demand (BOD) – the amount of oxygen required for biological decomposition of organic matter.

C-50 – a mixture of equal parts of a 38 wt% aqueous calcium chloride solution and Ice Ban™.

Cal Ban – a mixture of equal parts of 38 wt% aqueous calcium chloride ($CaCl_2$) and 6 wt% Ice Ban™.

chemical oxygen demand (COD) – the amount of oxygen required for abiotic oxidation of organic matter.

FreezGard – also known as FreezGard Zero, is a 30% aqueous magnesium chloride solution that is applied directly to ice and snow-packed highway surfaces.

Ice Ban – a commercial, grain-based anti-icing/anti-freezing agent.

leach – to remove soluble substances from soil by percolation.

M-50 – a mixture of equal parts of a 30 wt% aqueous magnesium chloride ($MgCl_2$) solution and Ice Ban™.

pore volume – the volume of pore space in the 5-foot tall, 6-inch diameter, sand-filled laboratory test columns, equal to approximately 5.859 liters.

Salt Ban – a mixture of sodium chloride salt and Ice Ban™.

Slow Set 1 (SS-1) – an asphalt emulsion consisting of 50% water and 50% road oil.

workability – the ability of stockpiled road sand material to resist freezing both at the surface and in the interior of the stockpile that allows ease of handling.

APPENDIX A

MANUFACTURER PRODUCT INFORMATION DATA SHEETS FOR ANTI-FREEZING AGENTS

ICE BAN

MSDS

ICE BAN AMERICA, INC.

Material Safety Data Sheet

ICE BAN™ Products

A. GENERAL INFORMATION

Trade Name (Common Name)	General Product Code #	
ICE BAN	N/A	
Chemical Name and/or Synonym		
Fermented Grain Extractives, Grain Steep Liquor, Brewers Soluables, Vintners, Whey		
Formula	**Molecular Weight**	
N/A	N/A	
Address (No., Street, City, State and Zip Code)		**Fax**
ICE BAN AMERICA, INC., P.O. Box 14245, North Palm Beach, FL 33408		561-625-4989
Product Information	**Emergency Number**	**Last Issue Date** / **Current Issue Date**
561-625-4232	888-423-2261	N/A / 01/01/97

B. FIRST AID MEASURES

ICE BAN de-icing products are non-toxic, non-corrosive and non-reactive.
No hazard warning is required for these products except for restrictions regarding entering any storage tanks.

REFER TO SECTION D - STORAGE.

C. HAZARDS INFORMATION - HEALTH

Inhalation
N/A

Ingestion
If swallowed, no first aid procedures are required. If ingested in large quantities, some ICE BAN products may cause diarrhea.

Skin
N/A

Eyes
No first aid procedures are required. Flush eyes with water for 10 minutes. If contacts are worn, remove and clean.

Permissible Concentration: Air	Biological
None established	None

Unusual Chronic Toxicity
None known

Flash Point	Auto Ignition Temperature	Flammable Limits in Air (% By Vol)
N/A	N/A	Lower - N/A Upper - N/A

Unusual Fire and Explosion Hazards
None

D. PRECAUTIONS / PROCEDURES

Fire Extinguishing Agent Recommended
N/A

Fire Extinguishing Agents to Avoid
N/A

Special Fire Fighting Precautions
N/A

Ventilation
N/A

Normal Handling

Storage
Product is subject to slight fermentation, store in vented vessel or container.
NEVER ENTER ANY ICE BAN TRANSPORTATION OR STORAGE TANKS WITHOUT COMPLETELY VENTILATING THE TANK. CARBON DIOXIDE PRESENT IN TANKS CAN DISPLACE AIR.

Spill or Leak
If spilled or released, all legislative requirements for non-hazardous waste disposal should be followed.
Dilute with water and clean the spill.

Special Precautions/Procedures/Label Instructions
REFER TO SECTION D - STORAGE.

E. PERSONAL PROTECTIVE EQUIPMENT

Respiratory Protection
None required

Eyes and Face
None required

Hands, Arms and Body
None required

Other Clothing and Equipment
None

F. PHYSICAL DATA

Material is (At Normal Conditions):
Liquid

Appearance and Odor
Brown. Distinct odor.

Boiling Point N/A
Melting Point N/A

Specific Gravity
1.24 - 1.25

Vapor Density
N/A

Solubility in Water (% by Weight)
N/A

pH
4.0 Max

Vapor Pressure
N/A

Evaporation Rate
N/A

% Volatiles by Volume (At 20°C)
0

G. REACTIVITY DATA

Stability	Conditions to Avoid
Stable	None

Incompatibility

None

Hazardous Decomposition Products

None

Hazardous Polymerization	Conditions to Avoid
Will not occur	None

H. HAZARDOUS INGREDIENTS (Mixtures Only)

Material or Component /C.A.S. #	WT. %	Hazard Data (See Section J.)
N/A		

I. ENVIRONMENTAL

Degradability/Aquatic Toxicity	Octanol/Water Partition Coefficient
N/A	N/A

EPA Hazardous Substances (Clean Water Act Sec.311)

No

Waste Disposal Methods (Disposer Must Comply With Federal, State and Local Disposal or Discharge Laws)

RCRA Status of Unused Material if Discarded	Hazardous Waste Number:(If Applicable)
Not a hazardous waste.	

J. REFERENCES

Permissible Concentration References

None

Regulatory Standards

IATA: Not restricted.
ICE BAN products are included in the TSCA inventory (DSL in Canada) of chemical substances.

D.O.T. Classification:

Not restricted

General

ICE BAN America, Inc., Data, unpublished.

K. ADDITIONAL INFORMATION

THIS MATERIAL SAFETY DATA SHEET IS OFFERED SOLELY FOR YOUR INFORMATION, CONSIDERATION AND INVESTIGATION.

ICE BAN AMERICA, INC. PROVIDES NO WARRANTIES, EITHER EXPRESS OR IMPLIED, AND ASSUMES NO RESPONSIBILITY FOR THE ACCURACY OR COMPLETENESS OF THE DATA CONTAINED HEREIN.

ICE BAN™

PRODUCT DESCRIPTION:

ICE BAN™ is the concentrated liquid residue of fermentation and industrial processing of agricultural products. ICE BAN™ is inert, non-corrosive, non-toxic and environmentally friendly.

HEAVY METALS ANALYSIS:

ARSENIC	NOT DETECTABLE
BARIUM	NOT DETECTABLE
CADMIUM	NOT DETECTABLE
CHROMIUM	NOT DETECTABLE
COPPER	1.0 ppm
CYANIDE	0.18 ppm
LEAD	NOT DETECTABLE
MERCURY	NOT DETECTABLE
SELENIUM	NOT DETECTABLE
ZINC	20 ppm

ICE BAN AMERICA, INC.
CORPORATE OFFICE: 1201 U.S. Highway One, Suite 205; North Palm Beach, FL 33408; (888) ICEBAN-1; FAX (561) 625-4089
OPERATIONS OFFICE: 12118 E. Yates Road; Lyndonville, NY 14098; (800) 7-ICEBAN; FAX (716) 765-9576
PRODUCTION FACILITIES: Minnesota Corn Processors; Marshall, MN 56258; (800) 328-4150; FAX (507) 537-2641

FreezGard Zero

GREAT SALT LAKE MINERALS

FreezGard® Zero

More Product, Less Fallout

MATERIAL DATA SAFETY SHEET

May be used to comply with OSHA's Hazard Communication Standard, 229 CFR 1910.1200. Standard must be consulted for specific requirements.

SECTION I: PRODUCT IDENTIFICATION

Chemical Name:	Magnesium Chloride Solution 25% - 35%
Product Name:	FreezGard® Zero
Formula:	$MgCl_2$, H_2O
CAS Number:	7791-18-6: Magnesium Chloride Hexahydrate
	7732-18-5: Water
Manufacturer's Name:	Great Salt Lake Mineral's Corporation
Address:	765 North 10500 West, Ogden, Utah 84404
Information & Emergency Telephone:	801-731-3100
Date Prepared:	May 1, 1996

SECTION II: HAZARDOUS INGREDIENTS/IDENTITY INFORMATION

None

SECTION III: PHYSICAL/CHEMICAL CHARACTERISTICS

Boiling Point:	225 degrees F
Melting Point:	N/A
Vapor Pressure:	N/A
Vapor Density:	N/A
Evaporation Rate:	1
Solubility in Water:	100%
Specific Gravity (H_2O=1):	1.32
Odor and Appearance:	Liquid, slight yellow to colorless

SECTION IV: FIRE AND EXPLOSION HAZARD DATA

Flash Point:	None
Extinguishing Media:	None, Non-Flammable
Flammable Limits:	STP in Air
LEL:	N/A
UEL:	N/A
Special Fire Fighting Procedures:	None
Unusual Fire and Explosion Hazards:	None

National Fire Protection Association (NFPA) Classification:
4 = Severe, 3 = Serious, 2 = Moderate, 1 = Slight, 0 = Minimal

Health	1
Flammability	0
Reactivity	0

Hazardous Materials Information System (HMIS):
4 = Extreme, 3 = High, 2 = Moderate, 1 = Slight, 0 = Insignificant

Blue: (Acute Health)	1
Red (Flammability)	0
Yellow (Reactivity)	0

GREAT SALT LAKE MINERALS

SECTION V: REACTIVITY DATA

Stability:	Stable
Incompatibility (Materials to avoid):	Solution can be corrosive to some metals
Hazardous Decomposition or Byproducts:	Hydrogen chloride when heated
Hazardous Polymerization:	Will not occur

SECTION VI: HEALTH HAZARD DATA

Health Hazards (Acute and Chronic):	None
Carcinogenicity:	N/A
NTP:	N/A
IARC Monographs:	N/A
OSHA Regulated:	N/A
Signs and Symptoms of Exposure:	Ingestion: Oral ingestion of large doses may cause GI irritation.
	Skin: May cause irritation
	Eyes: May cause irritation
	Inhalation: N/A
Emergency and First Aid Procedures:	Ingestion: Low toxicity
	Skin: Flush with water
	Eyes: Irrigate with water
	Inhalation: N/A

SECTION VII: PRECAUTIONS FOR SAFE HANDLING AND USE

Steps to be Taken in Case Material is Released or Spilled:	No special precautions. Flush with water.
Waste Disposal Method:	Soluble in water - neutral or slightly basic solution occurs.
Precautions to Be Taken in Handling and Storage:	KEEP OUT OF THE REACH OF CHILDREN
	Material is deliquescent, so may cake with moisture and long term storage.
	Avoid contact with eye, skin or clothing.
	Wash thoroughly after handling.
	Practice reasonable care and precautions.
Other Precautions:	Not for food or drug use.
	Do not take internally.

SECTION VIII: CONTROL MEASURES

Respiratory Protection:	None
Ventilation: Local Exhaust:	N/A
Mechanical(General):	N/A
Special (Other):	N/A
Protective Gloves:	N/A
Eye Protection:	Safety galles with splash shields
Other Protective Clothing or Equipment:	None
Work/Hygienic Practices:	None

SECTION IX: SUPPLIER NOTIFICATION

Name:	Magnesium Chloride Solution FreezGard® Zero
Hazard Label:	None
Transportation Guidelines:	No special requirementsShipping

IMC Kalium Ogden Corp

FREEZGARD®-ZERO

DEICING LIQUID
Ogden, UT Production

PRODUCT DATA SHEET

95% statistical confidence level CAS#7786-30-3

CHEMICAL PROPERTIES

Chemical Composition	Typical Analysis %	Range (%)
*$MgCl_2$	31	30 - 32
SO_4	.7	.5 - .8
K	0.3	0.1 - 0.5
Na	0.3	0.1 - 0.7
H_2O	66	64 - 69
pH (5% solution)	7 - 9	
Specific Gravity	1.30 ± 0.02	
Weight	10.5-11.0 lbs/gallon	
Form	Solution	

*%Magnesium ion expressed as % $MgCl_2$. (%Mg X 3.916 = % $MgCl_2$)

PHYSICAL PROPERTIES

FreezGard®ZERO is formulated for deicing roads and as a side release agent in rail cars.

FreezGard®ZEROis formulated to minimize solid precipitates at cold temperatures. FreezGard®ZERO has a maximum potential to form 1% solids at 0 degrees F and 30% $MgCl_2$. Please consult the freeze/temperature chart for freeze points of other concentrations.

Maintenance of application and storage equipment:
In colder temperatures, periodic recirculation of the liquid in a storage tank should inhibit solid build up. It is advisable to wash or flush the application equipment with water after each days use. Storage equipment should be flushed at the end of the storage period. Aluminum storage tanks or hauling equipment should not be grounded. Spills should be flushed with water or sanded.

IMC Kalium Ogden Corp
P.O. Box 1190 * 765 North 10500 West * Ogden, UT 84402 * Tel.(800)453-4615
IMC 6/98

Calcium Chloride

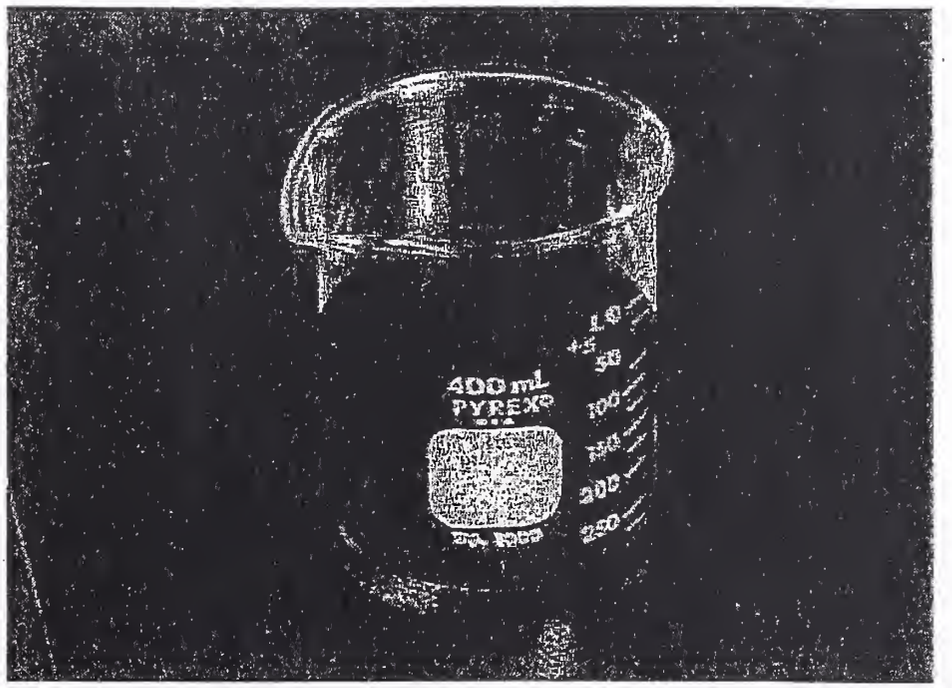
LIQUIDOW ARMOR Deicer

General Description

LIQUIDOW* ARMOR* Deicer is a patented, corrosion-inhibited, liquid calcium chloride solution which meets or exceeds the product specifications developed by the Pacific Northwest Snowfighters (PNS). These specifications require low heavy metal content, as shown in the chart below.

Element	Spec Limit (ppm)
Phosphorus	25.00 ppm
Cyanide	0.20 ppm
Arsenic	5.00 ppm
Copper	0.20 ppm
Lead	1.00 ppm
Mercury	0.05 ppm
Chromium	0.50 ppm
Cadmium	0.20 ppm
Barium	10.00 ppm
Selenium	5.00 ppm
Zinc	10.00 ppm

LIQUIDOW ARMOR Deicer also passes the PNS Total Settleable Solids test, which requires less than 1% crystallization after 7 days at -20 °F (-29 °C). In terms of temperature criteria, this PNS requirement for calcium chloride deicers is much more demanding than that required for other deicers, the next closest being 7 days at 0 °F (-18 °C) for liquid magnesium chloride deicers. Passing this test virtually assures the end user that LIQUIDOW ARMOR will not freeze in storage even under the severe winter conditions. LIQUIDOW ARMOR requires a minimum amount of agitation or recirculation while in storage to maintain uniform composition. Usually, mixing just prior to use is all that is recommended.



Applications

LIQUIDOW ARMOR Deicer was developed for winter road maintenance applications, including anti-icing and prewetting.

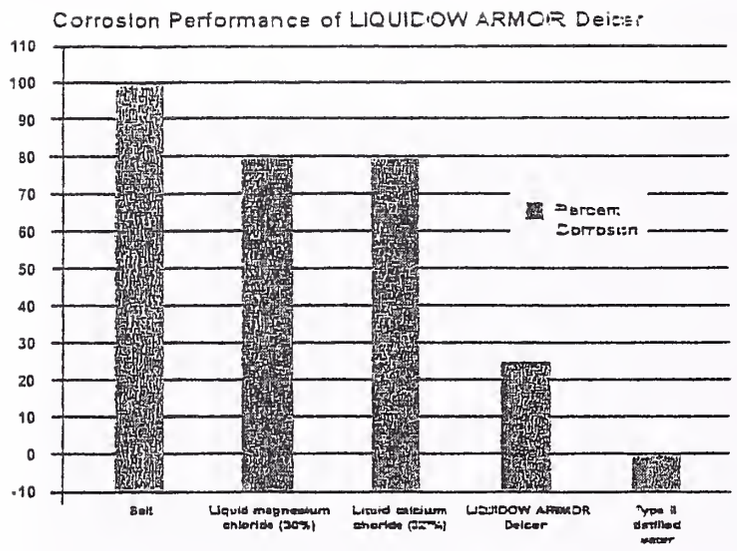
As an anti-icer, LIQUIDOW ARMOR Deicer is typically used at rates of 15 to 30 gallons per lane mile. The end user will want to adjust application rates based on experience, forecasted storm conditions and level or service goals.

As a prewetting agent, LIQUIDOW ARMOR Deicer is typically used at rates of 8-10 gallons per ton of material. Prewetting with LIQUIDOW ARMOR Deicer decreases the amount of salt and abrasives lost to bounce and scatter and increases the melt speed of salt.

Typical Properties

Appearance	Brown liquid
Odor	Slight
Specific Gravity	1.34
Density	11.2 lbs/gal
Calcium Chloride Content	30%
LC_{50}, Rainbow Trout	23,452 mg/L

*Trademark of The Dow Chemical Company



LIQUIDOW ARMOR DEICER

Pacific Northwest States Coalition Test Method

The test method that the PNS developed was based on NACE test TM-01-69 with a minor modification. Steel coupons are alternately immersed for 10 minutes in a prepared solution of deicer and water (3% by volume) and air dried for 50 minutes. This cycle is repeated for 72 hours at which time the coupons are cleaned, dried and weight loss measured. Absolute corrosion values are then scaled to set values for salt and water. A corrosion value of 70% less corrosive than rock salt is considered passing.

Availability

LIQUIDOW ARMOR Deicer is available in both rail car and tank trucks through the Dow Distributor Network.

Safety and Handling

For brief contact, no precautions other than clean body-covering clothing should be needed. Selection of specific items such as goggles, gloves, and apron will depend on the operation. Eye/face protection is recommended for handling solutions.

Appropriate ventilation should be in place to keep atmospheric levels below industrial hygiene guidelines (Dow IHG for calcium chloride is 10 mg/cu. meter).

Rubber boots and gloves are recommended due to the adverse effect of calcium chloride on leather.

Consult authorities for proper disposal information.

Friction Reduction Warning Statement

When following Federal Highway Administration guidelines[1] for anti-icing, users may choose to apply LIQUIDOW ARMOR to dry roads prior to the onset of a snow or ice storm. Application of LIQUIDOW ARMOR will result in a road surface that is more slippery than the same road in a dry condition. When used as directed, the application of LIQUIDOW ARMOR should provide traction comparable to a road surface that is wet with rainwater. Exceeding recommended application rates for LIQUIDOW ARMOR will result in additional reduction in road surface traction. Avoid applying LIQUIDOW ARMOR over excessive amounts of slippery road surface contaminants such as oil.

For full safety and handling details, contact The Dow Chemical Company for a current copy of the Material Safety Data Sheet for this product.

For more information contact The Dow Chemical Company Customer Information Center at 1-800-447-4369, or visit us on the web at www.dowcalciumchloride.com.

[1]Manual of Practice For an Effective Anti-icing Program: A Guide For Highway Winter Maintenance Personnel. Prepared for FHWA, February 22, 1996

NOTICE: No freedom from any patent owned by Seller or others is to be inferred. Because use conditions and applicable laws may differ from one location to another and may change with time, Customer is responsible for determining whether products and the information in this document are appropriate for Customer's use and for ensuring that Customer's workplace and disposal practices are in compliance with applicable laws and other governmental enactments. Seller assumes no obligation or liability for the information in this document. NO WARRANTIES ARE GIVEN; ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE ARE EXPRESSLY EXCLUDED.

Published May 2001.

DOW

Printed in U.S.A.

™Trademark of The Dow Chemical Company

Form No. 173-01613-501XQRP

Material Safety Data Sheet

1. CHEMICAL PRODUCT & COMPANY IDENTIFICATION

24-Hour Emergency Phone Number: 989-636-4400

Product: LIQUIDOW* ARMOR* DEICER

Product Code: 72065

Effective Date: 01/05/01 Date Printed: 11/30/01 MSD: 006591

The Dow Chemical Company, Midland, MI 48674

Customer Information Center: 800-258-2436

2. COMPOSITION/INFORMATION ON INGREDIENTS

Calcium chloride	CAS# 010043-52-4	29-31%
Potassium chloride	CAS# 007447-40-7	1-3%
Sodium chloride	CAS# 007647-14-5	1-4%
Proprietary ingredient		6.0-6.5%
Water	CAS# 007732-18-5	55-64%

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

****

* Brown liquid. Characteristic odor. Causes eye irritation. *

*

****

POTENTIAL HEALTH EFFECTS (See Section 11 for toxicological data.)

EYE: May cause severe irritation with corneal injury. Effects may be slow to heal.

SKIN: Short single exposure not likely to cause significant skin irritation. Prolonged or repeated exposure may cause skin irritation, even a burn. May cause more severe response if confined to skin or skin is abraded (scratched or cut). A single prolonged exposure is not likely to result in the material being absorbed through skin in harmful amounts.

INGESTION: Single dose oral toxicity is considered to be low. Small amounts swallowed incidental to normal handling operations are not likely to cause injury; swallowing amounts larger than that may cause injury. Ingestion may cause gastrointestinal

(Continued on page 2 , over)

* OR (R) INDICATES A TRADEMARK OF THE DOW CHEMICAL COMPANY

irritation or ulceration.

INHALATION: Mists may cause irritation of upper respiratory tract (nose and throat).

SYSTEMIC (OTHER TARGET ORGAN) EFFECTS: No relevant information found.

4. FIRST AID

EYES: Irrigate with flowing water immediately and continuously for 15 minutes. Consult medical personnel.

SKIN: Wash off in flowing water or shower.

INGESTION: Do not induce vomiting. Give large amounts of water or milk if available and transport to medical facility.

INHALATION: Remove to fresh air if effects occur. Consult a physician.

NOTE TO PHYSICIAN: No specific antidote. Supportive care. Treatment based on judgment of the physician in response to reactions of the patient.

5. FIRE FIGHTING MEASURES

FLAMMABLE PROPERTIES
FLASH POINT: Not applicable
METHOD USED: Not applicable
AUTOIGNITION TEMPERATURE: Not applicable

FLAMMABILITY LIMITS
LFL: Not applicable
UFL: Not applicable

HAZARDOUS COMBUSTION PRODUCTS: Not applicable.

OTHER FLAMMABILITY INFORMATION: This material does not burn. Violent steam generation or eruption may occur upon application of direct water stream to hot liquids.

EXTINGUISHING MEDIA: This material does not burn. If exposed to fire from another source, use suitable extinguishing agent for that fire.

(Continued on page 3)
* OR (R) INDICATES A TRADEMARK OF THE DOW CHEMICAL COMPANY

FIRE FIGHTING INSTRUCTIONS: Keep people away. Isolate fire area and deny unnecessary entry. This material does not burn. Fight fire for other material that is burning.

PROTECTIVE EQUIPMENT FOR FIRE FIGHTERS: Wear positive-pressure self-contained breathing apparatus (SCBA) and protective fire fighting clothing (includes fire fighting helmet, coat, pants, boots, and gloves . If protective equipment is not available or not used, fight fire from a protected location or safe distance.

6. ACCIDENTAL RELEASE MEASURES (See Section 15 for Regulatory Information)

PROTECT PEOPLE: Isolate area. Avoid contact with eyes and skin. May be a slipping hazard. Stop leak if it can be done safely. Wash exposed body areas thoroughly after handling. Use appropriate safety equipment. For additional information, refer to "Exposure Controls/Personnel Protection", MSDS Section 8.

PROTECT THE ENVIRONMENT: For small spills: Losses incidental to correct applications of this product in its intended uses are not expected to be harmful to the environment.

For large spills: Avoid contamination of drinking water, natural water, ground water or any waterway. Losses incidental to correct applications of this product in its intended uses are not expected to be harmful to the environment.

CLEANUP: For small spills: Contain spill if possible. Absorb with material such as sand. Collect material in suitable and and properly labeled open containers. Flush residue with plenty of water.

For large spills: Dike and transfer to suitable and properly labeled containers. Absorb with material such as sand. Flush residue with plenty of water.

7. HANDLING AND STORAGE

HANDLING: Refer to Exposure Controls/Personal Protection, Section 8, of the MSDS.

For more Storage and Handling information, refer to bulletin 173-01534.

(Continued on page 4 , over)
* OR (R) INDICATES A TRADEMARK OF THE DOW CHEMICAL COMPANY

STORAGE: For more storage and handling information, refer to product bulletin.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

ENGINEERING CONTROLS: Provide general and/or local exhaust ventilation to control airborne levels below the exposure guidelines.

PERSONAL PROTECTIVE EQUIPMENT

EYE/FACE PROTECTION: Use chemical goggles.

SKIN PROTECTION: When prolonged or frequently repeated contact could occur, use protective clothing impervious to this material. Selection of specific items such as gloves, boots, apron or full-body suit will depend on operation. If hands are cut or scratched, use gloves impervious to this material even for brief exposures. Use gloves with insulation for thermal protection, when needed.

RESPIRATORY PROTECTION: Atmospheric levels should be maintained below the exposure guideline. In misty atmospheres, use an approved mist respirator.

EXPOSURE GUIDELINES: Calcium chloride: Dow IHG is 10 mg/m3.
Sodium Chloride: Dow IHG is 10 mg/m3.
Potassium Chloride: Dow IHG is 10 mg/m3.

9. PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE/PHYSICAL STATE: Brown liquid.
ODOR: Characteristic.
VAPOR PRESS: 13-15 mmHg @ 25C, 77F.
VAPOR DENSITY: Same as water.
BOILING POINT: 230-235F, 110-113C
SOLUBILITY IN WATER: Completely miscible.
SPECIFIC GRAVITY: 1.31-1.36 @ 25C/70F

10. STABILITY AND REACTIVITY

CHEMICAL STABILITY: Stable. Hygroscopic.

CONDITIONS TO AVOID: None known.

INCOMPATIBILITY WITH OTHER MATERIALS: Flammable hydrogen may be

(Continued on page 5)
* OR (R) INDICATES A TRADEMARK OF THE DOW CHEMICAL COMPANY

generated from contact with metals such as zinc.

HAZARDOUS DECOMPOSITION PRODUCTS: Does not decompose.

HAZARDOUS POLYMERIZATION: Will not occur.

11. TOXICOLOGICAL INFORMATION (See Section 3 for Potential Health Effects. For detailed toxicological data, write or call the address or non-emergency number shown in Section 1)

SKIN: The LD50 for skin absorption in rabbits is > 5000 mg/kg for CaCl2.

INGESTION: The oral LD50 for rats is in the range of 900-2100 mg/kg for CaCl2 (100% basis).

MUTAGENICTY (EFFECTS ON GENETIC MATERIAL): For CaCl2, in vitro mutagenicity studies were negative.

12. ECOLOGICAL INFORMATION (For detailed Ecological data, write or call the address or non-emergency number shown in Section 1)

ENVIRONMENTAL FATE

MOVEMENT & PARTITIONING: Partitioning from water to n-octanol is not applicable.

DEGRADATION & TRANSFORMATION: Biodegradation is not applicable.

ECOTOXICOLOGY: Based largely or completely on data for major component(s). Material is practically non-toxic to aquatic organisms on an acute basis (LC50 greater than 100 mg/L in most sensitive species).

13. DISPOSAL CONSIDERATIONS (See Section 15 for Regulatory Information)

DISPOSAL: All disposal methods must be in compliance with all Federal, State/Provincial and local laws and regulations. Regulations may vary in different locations. Waste characterizations and compliance with applicable laws are the responsibility solely of the waste generator. THE DOW CHEMICAL COMPANY HAS NO CONTROL OVER THE MANAGEMENT PRACTICES OR MANUFACTURING PROCESSES OF PARTIES HANDLING OR USING THIS MATERIAL. THE INFORMATION PRESENTED HERE PERTAINS ONLY TO THE PRODUCT AS SHIPPED IN ITS INTENDED CONDITION AS DESCRIBED IN MSDS SECTION 2 (Composition/Information On Ingredients).

(Continued on page 6 , over)
* OR (R) INDICATES A TRADEMARK OF THE DOW CHEMICAL COMPANY

FOR UNUSED & UNCONTAMINATED PRODUCT, the preferred options include sending to a licensed, permitted: reclaimer or waste water treatment system.

For additional information, refer to:
- Handling & Storage Information, MSDS Section 7.
- Stability & Reactivity Information, MSDS Section 10.
- Regulatory Information, MSDS Section 15.

As a service to its customers, Dow can provide names of information resources to help identify waste management companies and other facilities which recycle, reprocess or manage chemicals or plastics, and that manage used drums. Telephone Dow's Customer Information Center at 800-258-2436 or 517-832-1556 for further details.

14. TRANSPORT INFORMATION

UNITED STATES DOT INFORMATION:
This product is not regulated by D.O.T. when shipped domestically by land.

CANADIAN TDG INFORMATION:
This product is not regulated by TDG when shipped domestically by land.

15. REGULATORY INFORMATION (Not meant to be all-inclusive--selected regulations represented)

NOTICE: The information herein is presented in good faith and believed to be accurate as of the effective date shown above. However, no warranty, express or implied is given. Regulatory requirements are subject to change and may differ from one location to another; it is the buyer's responsibility to ensure that its activities comply with federal, state or provincial, and local laws. The following specific information is made for the purpose of complying with numerous federal, state or provincial, and local laws and regulations. See other sections for health and safety information.

U.S. REGULATIONS
==========

SARA 313 INFORMATION: To the best of our knowledge, this product contains no chemical subject to SARA Title III Section 313 supplier notification requirements.

(Continued on page 7)
* OR (R) INDICATES A TRADEMARK OF THE DOW CHEMICAL COMPANY

Product: LIQUIDOW* ARMOR* DEICER
Product Code: 72065

Effective Date: 01/05/01 Date Printed: 11/30/01 MSD: 006591

REGULATORY INFORMATION (CONTINUED)

SARA HAZARD CATEGORY: This product has been reviewed according to the EPA "Hazard Categories" promulgated under Sections 311 and 312 of the Superfund Amendment and Reauthorization Act of 1986 (SARA Title III) and is considered, under applicable definitions, to meet the following categories:

An immediate health hazard
This product has been categorized as "an immediate health hazard" due to the possibility of eye or skin irritation.

TOXIC SUBSTANCES CONTROL ACT (TSCA):

All ingredients are on the TSCA inventory or are not required to be listed on the TSCA inventory.

STATE RIGHT-TO-KNOW: This product is not known to contain any substances subject to the disclosure requirements of

New Jersey
Pennsylvania

OSHA HAZARD COMMUNICATION STANDARD:

This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.
This product has been categorized as a "Hazardous Chemical" due to the possibility of eye or skin irritation.

COMPREHENSIVE ENVIRONMENTAL RESPONSE COMPENSATION AND LIABILITY ACT (CERCLA, or SUPERFUND):

To the best of our knowledge, this product contains no chemical subject

(Continued on page 8 , over)
* OR (R) INDICATES A TRADEMARK OF THE DOW CHEMICAL COMPANY

REGULATORY INFORMATION (CONTINUED)

to reporting under CERCLA.

CANADIAN REGULATIONS

WHMIS INFORMATION: The Canadian Workplace Hazardous Materials Information System (WHMIS) Classification for this product is:

D2B - eye or skin irritant
Refer elsewhere in the MSDS for specific warnings and safe handling information. Refer to the employer's workplace education program.

CPR STATEMENT: This product has been classified in accordance with the hazard criteria of the Canadian Controlled Products Regulations (CPR) and the MSDS contains all the information required by the CPR.

HAZARDOUS PRODUCTS ACT INFORMATION: This product contains the following ingredients which are Controlled Products and/or on the Ingredient Disclosure List (Canadian HPA section 13 and 14):

COMPONENTS:	CAS #	AMOUNT(%w/w)
Calcium chloride	CAS# 010043-52-4	29-31%

CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA):

All substances in this product are listed on the Canadian Domestic Substances List (DSL) or are not required to be listed.

16. OTHER INFORMATION

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) RATINGS:

Health	1
Flammability	0
Reactivity	0

MSDS STATUS: Revised Sections 2, 3, 4, 7, 8, 9, 13 and 15.

* OR (R) INDICATES A TRADEMARK OF THE DOW CHEMICAL COMPANY
The Information Herein Is Given In Good Faith, But No Warranty, Express Or Implied, Is Made. Consult The Dow Chemical Company For Further Information.

Material Safety Data Sheet

The Dow Chemical Company
Midland, Michigan 48674

1. CHEMICAL PRODUCT & COMPANY IDENTIFICATION

24-Hour Emergency Phone Number: 517-636-4400

Product: LIQUIDOW* TECHNICAL GRADE CALCIUM CHLORIDE SOLUTION

Product Code: 45297

Effective Date: 02/03/98 Date Printed: 02/09/98 MSD: 005489

The Dow Chemical Company, Midland, MI 48674

Customer Information Center: 800-258-2436

2. COMPOSITION/INFORMATION ON INGREDIENTS

Calcium chloride	CAS# 010043-52-4	28-45%
Potassium chloride	CAS# 007447-40-7	0-3%
Sodium chloride	CAS# 007647-14-5	0-2%
Water	CAS# 007732-18-5	

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

****

* Colorless to pale yellow liquid. Odorless. Causes eye irritation. *

*

****

POTENTIAL HEALTH EFFECTS (See Section 11 for toxicological data.)

EYE: Material may be handled at elevated temperatures; contact with heated material may cause thermal burns. May cause severe irritation with corneal injury. Effects may be slow to heal.

SKIN: Short single exposure not likely to cause significant skin irritation. Prolonged or repeated exposure may cause skin irritation, even a burn. May cause more severe response if confined to skin or skin is abraded (scratched or cut). Material may be handled at elevated temperatures; contact with heated material may cause thermal burns. A single prolonged exposure is not likely to result in the material being absorbed through skin in harmful amounts. Not classified as corrosive according to DOT.

(Continued on page 2 , over)

(R) Indicates a Trademark of The Dow Chemical Company

INGESTION: Single dose oral toxicity is believed to be low. Small amounts swallowed incidental to normal handling operations are not likely to cause injury; swallowing amounts larger than that may cause injury. Ingestion may cause gastrointestinal irritation or ulceration.

INHALATION: Vapors are unlikely due to physical properties. Mists may cause irritation to upper respiratory tract.

SYSTEMIC (OTHER TARGET ORGAN) EFFECTS: No relevent information found.

4. FIRST AID

EYES: Irrigate with flowing water immediately and continuously for 15 minutes. Consult medical personnel.

SKIN: Wash off in flowing water or shower.

INGESTION: Do not induce vomiting. Give large amounts of water or milk if available and transport to medical facility.

INHALATION: Remove to fresh air if effects occur. Consult a physician.

NOTE TO PHYSICIAN: If burn is present, treat as any thermal burn, after decontamination. May cause tissue destruction leading to stricture. If lavage is performed, suggest endotracheal and/or esophageal control. No specific antidote. Supportive care. Treatment based on judgment of the physician in response to reactions of the patient.

5. FIRE FIGHTING MEASURES

FLAMMABLE PROPERTIES
FLASH POINT: Not applicable.
METHOD USED: Not applicable.

FLAMMABILITY LIMITS
LFL: Not applicable.
UFL: Not applicable.

HAZARDOUS COMBUSTION PRODUCTS: Not applicable.

EXTINGUISHING MEDIA: This material does not burn. If exposed to fire from another source, use suitable extinguishing agent for

(Continued on page 3)
(R) Indicates a Trademark of The Dow Chemical Company

that fire.

FIRE FIGHTING INSTRUCTIONS: Keep people away. Isolate fire area and deny unnecessary entry.

PROTECTIVE EQUIPMENT FOR FIRE FIGHTERS: Wear positive-pressure self-contained breathing apparatus (SCBA) and full protective fire fighting clothing (includes fire fighting helmet, coat, pants, boots, and gloves).

6. ACCIDENTAL RELEASE MEASURES (See Section 15 for Regulatory Information)

PROTECT PEOPLE: Isolate area. Avoid contact with eyes and skin. May be a slipping hazard. Stop leak if it can be done safely. Wash exposed body areas thoroughly after handling. Use appropriate safety equipment. For additional information, refer to "Exposure Controls/Personnel Protection", MSDS Section 8.

PROTECT THE ENVIRONMENT: For small spills: Losses incidental to correct applications of this product in its intended uses are not expected to be harmful to the environment.

For large spills: Avoid contamination of drinking water, natural water, ground water or any waterway. Losses incidental to correct applications of this product in its intended uses are not expected to be harmful to the environment.

CLEANUP: For small spills: Contain spill if possible. Absorb with material such as sand. Collect material in suitable and and properly labeled open containers. Flush residue with plenty of water.

For large spills: Dike and transfer to suitable and properly labeled containers. Absorb with material such as sand. Flush residue with plenty of water.

7. HANDLING AND STORAGE

HANDLING: Product shipped/handled hot can cause thermal burns. Refer to Exposure Controls/Personal Protection, Section 8, of the MSDS.

For more Storage and Handling information refer to bulletin 173-01534.

(Continued on page 4 , over)
(R) Indicates a Trademark of The Dow Chemical Company

STORAGE: Product may become a solid at temperatures below 32F, 0C (concentrations above 36% calcium chloride).

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

ENGINEERING CONTROLS: Provide general and/or local exhaust ventilation to control airborne levels below the exposure guidelines.

PERSONAL PROTECTIVE EQUIPMENT
EYE/FACE PROTECTION: Use chemical goggles.

SKIN PROTECTION: When prolonged or frequently repeated contact could occur, use protective clothing impervious to this material. Selection of specific items such as gloves, boots, apron or full-body suit will depend on operation. If hands are cut or scratched, use gloves impervious to this material even for brief exposures. Use gloves with insulation for thermal protection, when needed.

RESPIRATORY PROTECTION: Atmospheric levels should be maintained below the exposure guideline. When respiratory protection is required for certain operations, use an approved air-purifying respirator. In misty atmospheres, use an approved mist respirator.

EXPOSURE GUIDELINES: Calcium chloride: Dow IHG is 10 mg/m3.
Sodium Chloride: Dow IHG is 10 mg/m3.
Potassium Chloride: Dow IHG is 10 mg/m3.

9. PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE/PHYSICAL STATE: Colorless to pale yellow liquid.
ODOR: None.
VAPOR PRESS: 7-15 mmHg @ 25C, 77F.
VAPOR DENSITY: Same as water.
BOILING POINT: 230-251F, 110-122C
SOLUBILITY IN WATER: Completely miscible.
SPECIFIC GRAVITY: 1.297-1.437 @ 25C/70F

10. STABILITY AND REACTIVITY

CHEMICAL STABILITY: Stable. Hygroscopic.

CONDITIONS TO AVOID: None known.

(Continued on page 5)
(R) Indicates a Trademark of The Dow Chemical Company

INCOMPATIBILITY WITH OTHER MATERIALS: Corrosive to some metals. Avoid contact with metals such as: brass, mild steel, aluminum, or ferrous metals. Flammable hydrogen may be generated from contact with metals such as zinc or sodium. Avoid contact with sulfuric acid.

HAZARDOUS DECOMPOSITION PRODUCTS: Does not decompose.

HAZARDOUS POLYMERIZATION: Will not occur.

11. TOXICOLOGICAL INFORMATION (See Section 3 for Potential Health Effects. For detailed toxicological data, write or call the address or non-emergency number shown in Section 1)

ACUTE

SKIN: The LD50 for skin absorption in rabbits is >5000 mg/kg for CaCl2.

INGESTION: The oral LD50 for rats is in the range of 900-2100 mg/kg for CaCl2 (100% basis).

MUTAGENICTY (EFFECTS ON GENETIC MATERIAL): For CaCl2, in vitro mutagenicity studies were negative.

12. ECOLOGICAL INFORMATION (For detailed Ecological data, write or call the address or non-emergency number shown in Section 1)

ENVIRONMENTAL FATE

MOVEMENT & PARTITIONING: Partitioning from water to n-octanol is not applicable.

DEGRADATION & TRANSFORMATION: Biodegradation is not applicable.

ECOTOXICOLOGY: Based largely or completely on data for major component(s). Material is practically non-toxic to aquatic organisms on an acute basis (LC50 greater than 100 mg/L in most sensitive species).

13. DISPOSAL CONSIDERATIONS (See Section 15 for Regulatory Information)

DISPOSAL: DO NOT DUMP INTO ANY SEWERS, ON THE GROUND, OR INTO ANY BODY OF WATER. All disposal methods must be in compliance with all Federal, State/Provincial and local laws and regulations. Regulations may vary in different locations. Waste characterizations and compliance with applicable laws are the responsibility solely of the waste generator. THE DOW CHEMICAL COMPANY

(Continued on page 6 , over)
(R) Indicates a Trademark of The Dow Chemical Company

HAS NO CONTROL OVER THE MANAGEMENT PRACTICES OR MANUFACTURING PROCESSES OF PARTIES HANDLING OR USING THIS MATERIAL. THE INFORMATION PRESENTED HERE PERTAINS ONLY TO THE PRODUCT AS SHIPPED IN ITS INTENDED CONDITION AS DESCRIBED IN MSDS SECTION 2 (Composition/Information On Ingredients).

FOR UNUSED & UNCONTAMINATED PRODUCT, the preferred options include sending to a licensed, permitted: reclaimer or waste water treatment system.

For additional information, refer to:
- Handling & Storage Information, MSDS Section 7.
- Stability & Reactivity Information, MSDS Section 10.
- Regulatory Information, MSDS Section 15.

As a service to its customers, Dow can provide lists of companies which recycle, reprocess or manage chemicals or plastics, and companies that manage used drums. Telephone Dow's Customer Information Center at 800-258-2436 or 517-832-1556 for further details.

14. TRANSPORT INFORMATION

UNITED STATES DOT INFORMATION:
This product is not regulated by D.O.T. when shipped domestically by land.

CANADIAN TDG INFORMATION:
This product is not regulated by T.D.G. when shipped domestically by land.

15. REGULATORY INFORMATION (Not meant to be all-inclusive--selected regulations represented)

NOTICE: The information herein is presented in good faith and believed to be accurate as of the effective date shown above. However, no warranty, express or implied is given. Regulatory requirements are subject to change and may differ from one location to another; it is the buyer's responsibility to ensure that its activities comply with federal, state or provincial, and local laws. The following specific information is made for the purpose of complying with numerous federal, state or provincial, and local laws and regulations. See other sections for health and safety information.

U.S. REGULATIONS

(Continued on page 7)
(R) Indicates a Trademark of The Dow Chemical Company

Product: LIQUIDOW* TECHNICAL GRADE CALCIUM CHLORIDE SOLUTION
Product Code: 45297

Effective Date: 02/03/98 Date Printed: 02/09/98 MSD: 005489

REGULATORY INFORMATION (CONTINUED)

SARA 313 INFORMATION: To the best of our knowledge, this product contains no chemical subject to SARA Title III Section 313 supplier notification requirements.

SARA HAZARD CATEGORY: This product has been reviewed according to the EPA "Hazard Categories" promulgated under Sections 311 and 312 of the Superfund Amendment and Reauthorization Act of 1986 (SARA Title III) and is considered, under applicable definitions, to meet the following categories:

An immediate health hazard
This product has been categorized as "an immediate health hazard" due to the possibility of eye or skin irritation.

TOXIC SUBSTANCES CONTROL ACT (TSCA):

All ingredients are on the TSCA inventory or are not required to be listed on the TSCA inventory.

The CAS number(s) for TSCA is(are):
CAS# 010043-52-4
CAS# 007447-40-7
CAS# 007647-14-5
CAS# 007732-18-5

STATE RIGHT-TO-KNOW: This product is not known to contain any substances subject to the disclosure requirements of

New Jersey
Pennsylvania

OSHA HAZARD COMMUNICATION STANDARD:

This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.
This product has been categorized as a "Hazardous Chemical" due

(Continued on page 8 , over)
(R) Indicates a Trademark of The Dow Chemical Company

Product: LIQUIDOW* TECHNICAL GRADE CALCIUM CHLORIDE SOLUTION
Product Code: 45297

Effective Date: 02/03/98 Date Printed: 02/09/98 MSD: 005489

REGULATORY INFORMATION (CONTINUED)

to the possibility of eye or skin irritation.

COMPREHENSIVE ENVIRONMENTAL RESPONSE COMPENSATION AND LIABILITY ACT (CERCLA, or SUPERFUND):

To the best of our knowledge, this product contains no chemical subject to reporting under CERCLA.

CANADIAN REGULATIONS

WHMIS INFORMATION: The Canadian Workplace Hazardous Materials Information System (WHMIS) Classification for this product is:

D2B - eye or skin irritant
Refer elsewhere in the MSDS for specific warnings and safe handling information. Refer to the employer's workplace education program.

- - - - -

CPR STATEMENT: This product has been classified in accordance with the hazard criteria of the Canadian Controlled Products Regulations (CPR) and the MSDS contains all the information required by the CPR.

- - - - -

HAZARDOUS PRODUCTS ACT INFORMATION: This product contains the following ingredients which are Controlled Products and/or on the Ingredient Disclosure List (Canadian HPA section 13 and 14):

COMPONENTS:	CAS #	AMOUNT (%w/w)
Calcium Chloride	CAS# 010043-52-4	28-45%

16. OTHER INFORMATION

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) RATINGS:

Health	1
Flammability	0
Reactivity	0

MSDS STATUS: Revised section 16 (NFPA ratings).

(R) Indicates a Trademark of The Dow Chemical Company
The Information Herein Is Given In Good Faith, But No Warranty, Express Or Implied, Is Made. Consult The Dow Chemical Company For Further Information.

APPENDIX B

SAND AGGREGATE LABORATORY REPORT

MAXIM TECHNOLOGIES INC

Maxim Technologies
303 Irene Street PO Box 4699
Helena, MT 59604
Telephone: (406) 443-5210
FAX: (406) 449-3729

REPORT OF LABORATORY ANALYSIS OF AGGREGATE

CLIENT: MT. DEPT. OF TRANSPORTATION
C/O MAXIM TECHNOLOGIES
P.O. BOX 4699
HELENA, MT 59604

PROJECT: MDT COLUMNS

PROJECT NO.: 9911852
REPORT NO.: 6369
DATE OF SERVICE: 12/06/1999
AUTHORIZATION: MT. DEPT. OF TRANSPORTATION
REPORT DATE: 12/14/1999

SERVICES: Perform sieve analysis of coarse and fine aggregate and moisture content tests in accordance with ASTM C136 and C117 and D2216, respectively.

REPORT OF TESTS

MDT Column Tests
Lab No. 6369

SIEVE ANALYSIS Sieve Size	PERCENT PASSING
3/8"	100
No.4	75
No.10	54
No.20	41
No.40	28
No.80	13
No.200	7.2
MOISTURE CONTENT, % (As Received)	3.3

Technician: Edward Johnson
Engineering Technician

Report Distribution:
(01 MT. DEPT. OF TRANSPORTATION

MAXIM TECHNOLOGIES INC.

Jeremiah B. Bowser
Engineering Manager

Our letters and reports are for the exclusive use of the client to whom they are addressed and shall not be reproduced except in full without the approval of the testing laboratory. The use of our name must receive our written approval. Our letters and reports apply only to the sample tested and/or inspected, and are not indicative of the quantities of apparently identical or similar products.

098 EJ

APPENDIX C

LABORATORY ANALYTICAL REPORTS FOR COLUMN TEST SAND SAMPLES

NORTHERN
Analytical Laboratories, Inc.

602 South 25th Street
P O Box 30315
Billings, MT 59107
Telephone: (406) 254-7226
Fax: (406) 254-1389

REPORT TO: ATTN: TOM TANGEN
MAXIM TECHNOLOGIES, INC.
P O BOX 4699
HELENA MT 59604

DATE: January 27, 2000
JOB NUMBER: 87-911
SHEET: 1 of 7
INVOICE NO.: 25516985

REPORT OF: Soil Analysis - MDT Roadsalt Columns - 9911852.100

CASE NARRATIVE:

On December 28, 1999, these soil samples (laboratory numbers 220930 through 220934) were received in our laboratory for analysis. Tests were conducted in accordance with EPA/600/4-79-020 *"Methods for Chemical Analysis of Water and Wastes"; "Standard Methods for the Examination of Water and Wastewater"*, 18th Edition; SW-846 *"Test Methods for Evaluating Solid Waste"*, 3rd Edition, updates I, II, IIA, IIB, III and Western States Laboratory Proficiency Testing Program, *"Soil & Plant Analytical Methods"*.

The condition of the samples upon receipt at the laboratory is noted on the attached sample receipt checklist. Chain of custody documentation is enclosed.

The test results are shown on the following pages.

A < sign indicates the value reported was the practical quantitation limit for this sample using the method described. Concentrations of analyte, if present, below this were not quantifiable.

Footnote: (1) Insufficient sample was available to complete this test.

Reviewed by _____
Kathleen A. Smit – Laboratory Manager

RECEIVED
FEB 02 2000
MAXIM TECHNOLOGIES
HELENA, MT

Attachments: Chain of Custody
Sample Receipt Checklist

caj

As a mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of our clients and authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved pending our written approval. Test results apply specifically to the samples tested only. The entire report shall not be reproduced, except in full, without the written approval of the laboratory. Samples will be disposed of after testing is completed unless other arrangements are agreed to in writing.

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 220930
Sample Name: COLUMN #2
Sample Date: 11/22/99
Collected by: TOM TANGEN
Time Sampled: NONE GIVEN
Sample Type: SOIL

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	4	mg/kg	2320B	01/07/00
Alkalinity Carbonate as CO3	0	mg/kg	2320B	01/07/99
Alkalinity Total as CaCO3	3	mg/kg	2320B	01/07/00
CATIONS				
Calcium dry basis	12100	mg/kg	6010B	01/12/00
Magnesium dry basis	4340	mg/kg	6010B	01/12/00
Sodium dry basis	15400	mg/kg	6010B	01/12/00
ICP/AA Digestion Date	01/11/00		3050B	
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/10/00
NUTRIENTS				
Nitrate + Nitrite as N	13	mg/kg	353.2	01/07/00
Phosphorous Total	790	mg/kg	365.2	01/17/00
SOIL				
Chloride (Water Soluble)	26500	mg/kg	325.3	01/06/00
Chemical Oxygen Demand	7410	mg/kg	410.1	01/07/00
Organic Carbon	0.36	%	S-9.10	01/11/00
pH Saturated Paste	6.9	S.U.	S-1.10	01/07/00
Sulfate Water Soluble	<0.01	%	375.2	01/11/00

mmpy – means millimeters of corrosion of a steel coupon per year.

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 220931
Sample Name: COLUMN #4
Sample Date: 11/22/99
Collected by: TOM TANGEN
Time Sampled: NONE GIVEN
Sample Type: SOIL

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	118	mg/kg	2320B	01/07/00
Alkalinity Carbonate as CO3	0	mg/kg	2320B	01/07/99
Alkalinity Total as CaCO3	96	mg/kg	2320B	01/07/00
CATIONS				
Calcium dry basis	15300	mg/kg	6010B	01/12/00
Magnesium dry basis	4080	mg/kg	6010B	01/12/00
Sodium dry basis	1200	mg/kg	6010B	01/12/00
ICP/AA Digestion Date	01/11/00		3050B	
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/10/00
NUTRIENTS				
Nitrate + Nitrite as N	72	mg/kg	353.2	01/07/00
Phosphorous Total	740	mg/kg	365.2	01/17/00
SOIL				
Chloride (Water Soluble)	6030	mg/kg	325.3	01/06/00
Chemical Oxygen Demand	14700	mg/kg	410.1	01/07/00
Organic Carbon	0.44	%	S-9.10	01/11/00
pH Saturated Paste	7.2	S.U.	S-1.10	01/07/00
Sulfate Water Soluble	0.02	%	375.2	01/11/00

mmpy – means millimeters of corrosion of a steel coupon per year.

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 220932
Sample Name: COLUMN #5
Sample Date: 11/22/99
Collected by: TOM TANGEN
Time Sampled: NONE GIVEN
Sample Type: SOIL

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	23	mg/kg	2320B	01/07/00
Alkalinity Carbonate as CO3	0	mg/kg	2320B	01/07/99
Alkalinity Total as CaCO3	19	mg/kg	2320B	01/07/00
CATIONS				
Calcium dry basis	16700	mg/kg	6010B	01/12/00
Magnesium dry basis	4380	mg/kg	6010B	01/12/00
Sodium dry basis	950	mg/kg	6010B	01/12/00
ICP/AA Digestion Date	01/11/00		3050B	
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/11/00
NUTRIENTS				
Nitrate + Nitrite as N	11	mg/kg	353.2	01/07/00
Phosphorous Total	780	mg/kg	365.2	01/17/00
SOIL				
Chloride (Water Soluble)	8920	mg/kg	325.3	01/06/00
Chemical Oxygen Demand	6440	mg/kg	410.1	01/07/00
Organic Carbon	0.25	%	S-9.10	01/11/00
pH Saturated Paste	7.1	S.U.	S-1.10	01/07/00
Sulfate Water Soluble	<0.01	%	375.2	01/11/00

mmpy – means millimeters of corrosion of a steel coupon per year.

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 220933
Sample Name: COLUMN #6
Sample Date: 11/22/99
Collected by: TOM TANGEN
Time Sampled: NONE GIVEN
Sample Type: SOIL

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	275	mg/kg	2320B	01/07/00
Alkalinity Carbonate as CO3	0	mg/kg	2320B	01/07/99
Alkalinity Total as CaCO3	225	mg/kg	2320B	01/07/00
CATIONS				
Calcium dry basis	14000	mg/kg	6010B	01/12/00
Magnesium dry basis	6180	mg/kg	6010B	01/12/00
Sodium dry basis	1440	mg/kg	6010B	01/12/00
ICP/AA Digestion Date	01/11/00		3050B	
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/11/00
NUTRIENTS				
Nitrate + Nitrite as N	66	mg/kg	353.2	01/07/00
Phosphorous Total	800	mg/kg	365.2	01/17/00
SOIL				
Chloride (Water Soluble)	31700	mg/kg	325.3	01/06/00
Chemical Oxygen Demand	12400	mg/kg	410.1	01/07/00
Organic Carbon	0.39	%	S-9.10	01/11/00
pH Saturated Paste	7.7	S.U.	S-1.10	01/07/00
Sulfate Water Soluble	0.02	%	375.2	01/11/00

mmpy – means millimeters of corrosion of a steel coupon per year.

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 220934
Sample Name: COLUMN #7
Sample Date: 11/22/99
Collected by: TOM TANGEN
Time Sampled: NONE GIVEN
Sample Type: SOIL

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	27	mg/kg	2320B	01/07/00
Alkalinity Carbonate as CO3	0	mg/kg	2320B	01/07/99
Alkalinity Total as CaCO3	22	mg/kg	2320B	01/07/00
CATIONS				
Calcium dry basis	10800	mg/kg	6010B	01/12/00
Magnesium dry basis	7190	mg/kg	6010B	01/12/00
Sodium dry basis	1070	mg/kg	6010B	01/12/00
ICP/AA Digestion Date	01/11/00		3050B	
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/12/00
NUTRIENTS				
Nitrate + Nitrite as N	10	mg/kg	353.2	01/07/00
Phosphorous Total	780	mg/kg	365.2	01/17/00
SOIL				
Chloride (Water Soluble)	11000	mg/kg	325.3	01/06/00
Chemical Oxygen Demand	7940	mg/kg	410.1	01/07/00
Organic Carbon	0.25	%	S-9.10	01/11/00
pH Saturated Paste	7.3	S.U.	S-1.10	01/07/00
Sulfate Water Soluble	<0.01	%	375.2	01/11/00

mmpy – means millimeters of corrosion of a steel coupon per year.

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 220935
Sample Name: DUPLICATE OF 220930
Sample Date: 11/22/99
Collected by: TOM TANGEN
Time Sampled: NONE GIVEN
Sample Type: SOIL

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	NA			
Alkalinity Carbonate as CO3	NA			
Alkalinity Total as CaCO3	NA			
CATIONS				
Calcium dry basis	13200	mg/kg	6010B	01/12/00
Magnesium dry basis	4660	mg/kg	6010B	01/12/00
Sodium dry basis	16400	mg/kg	6010B	01/12/00
ICP/AA Digestion Date	01/11/00		3050B	
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/11/00
NUTRIENTS				
Nitrate + Nitrite as N	69	mg/kg	353.2	01/07/00
Phosphorous Total	770	mg/kg	365.2	01/17/00
SOIL				
Chloride (Water Soluble)	5510	mg/kg	325.3	01/06/00
Chemical Oxygen Demand	7550	mg/kg	410.1	01/07/00
Organic Carbon	0.39	%	S-9.10	01/11/00
pH Saturated Paste	(1)			
Sulfate Water Soluble	<0.01	%	375.2	01/11/00

mmpy – means millimeters of corrosion of a steel coupon per year.

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221029
Sample Name: COLUMN #1
Sample Date: 12/14/99
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: SOIL

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	7.4	mg/kg	2320B	01/07/00
Alkalinity Carbonate as CO3	0	mg/kg	2320B	01/11/00
Alkalinity Total as CaCO3	6.0	mg/kg	2320B	01/07/00
CATIONS				
Calcium dry basis	12,300	mg/kg	6010B	01/12/00
Magnesium dry basis	4510	mg/kg	6010B	01/12/00
Sodium dry basis	1030	mg/kg	6010B	01/12/00
ICP/AA Digestion Date	01/11/00		3050B	
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/25/00
NUTRIENTS				
Nitrate + Nitrite as N	11	mg/kg	353.2	01/07/00
Phosphorous Total	860	mg/kg	365.2	01/17/00
SOIL				
Chloride (Water Soluble)	525	mg/kg	325.3	01/18/00
Chemical Oxygen Demand	7590	mg/kg	410.1	02/04/00
Organic Carbon	0.24	%	S-9.10	01/11/00
pH Saturated Paste	8.1	S.U.	S-1.10	01/07/00
Sulfate Water Soluble	<0.01	%	375.2	01/11/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221030
Sample Name: COLUMN #1 (LABELED 3)
Sample Date: 12/14/99
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: SOIL

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	23	mg/kg	2320B	01/07/00
Alkalinity Carbonate as CO3	0	mg/kg	2320B	01/11/00
Alkalinity Total as CaCO3	19	mg/kg	2320B	01/07/00
CATIONS				
Calcium dry basis	12,000	mg/kg	6010B	01/12/00
Magnesium dry basis	4220	mg/kg	6010B	01/12/00
Sodium dry basis	16,100	mg/kg	6010B	01/12/00
ICP/AA Digestion Date	01/11/00		3050B	
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/27/00
NUTRIENTS				
Nitrate + Nitrite as N	16	mg/kg	353.2	01/07/00
Phosphorous Total	830	mg/kg	365.2	01/17/00
SOIL				
Chloride (Water Soluble)	20,700	mg/kg	325.3	01/18/00
Chemical Oxygen Demand	8920	mg/kg	410.1	02/04/00
Organic Carbon	0.36	%	S-9.10	01/11/00
pH Saturated Paste	7.1	S.U.	S-1.10	01/07/00
Sulfate Water Soluble	<0.01	%	375.2	01/11/00

mmpy – millimeters of corrosion of a steel coupon per year

ATTACHMENTS

CHAIN OF CUSTODY RECORD

MAXIM TECHNOLOGIES INC

600 South 25th Street
Billings, Montana 59101
Phone (406) 248-9161 • Fax (406) 248-9282

MDT roadsalt columns.
Project or Site Name

9911852-100
Project Number

Tom Tangen.
Sampler Name (Printed)

Contact Name

Box 4699
Report to (Firm or Agency)

Helena, MT 59604.
Address

443-5210
Sampler Signature

DATE COLLECTED	TIME COLLECTED	SAMPLE LOCATION OR DESCRIPTION	COMP OR GRAB	SAMPLE MATRIX	NO. OF CONTAINERS	ANALYSIS REQUIRED	NOTES	LAB NUMBER
11/22/99	—	column #1	grab	soil	1		lost in shipment*	
11/21/99	—	column #2	grab	soil	1			220930
11/21/99	—	column #3	grab	soil	1		lost in shipment*	
11/21/99	—	column #4	grab	soil	1			220931
11/22/99	—	column #5	grab	soil	1			932
11/22/99	—	column #6	grab	soil	1			933
11/22/99	—	column #7	grab	soil	1			934
							duplicate 220930	935

	Date	Time	Received by:
Relinquished by:	12/27/99	1:45 PM.	UPS
Relinquished by: UPS	12/29/99	1000	Barbara Hebert
Relinquished by:	Date	Time	Received by:
Relinquished by:	Date	Time	Received by:

Remarks:
parameter list attached

* sample jars broken in shipment due to no packing material in cooler. 01/12/28

NORTHERN Analytical Laboratories, Inc.

SAMPLE RECEIPT CHECKLIST

Dear Valued Client: This checklist documents the condition of your sample(s) as it (they) arrived at our lab. Please review it and familiarize yourself with its contents. Should you have any questions or comments, please contact us. Thank you for your use of our services.

Client Name: M-Helena

Project: MDT roadsalt Columns

Laboratory Number(s): 220930-35,36-43

Checklist Completed by: BH 12/28/99 (Initials / Date)

Date/Time Received: 12/28/99 (Date) 1000 (Time)

Received by: BH

Carrier Name: UPS

Sample Type: soil/water

	YES	NO
1. Shipping container in good condition?	X	
2. Custody seals present on shipping container? Condition: Intact ____ Broken ____		X
3. Chain of custody present?	X	
4. Chain of custody signed when relinquished and received?	X	
5. Chain of custody agrees with sample labels?	X	
6. Custody seals on sample bottles? Condition: Intact ____ Broken ____		X
7. Samples in proper container/bottle?*	X	
8. Sample containers intact?* See below		X
9. Sufficient sample volume for indicated test?*	X	
10. Ice/~~Frozen~~ Blue Ice present in shipping container? (circle one) 2.3°C container temperature 1. ~~4.6~~ 2. ____ 3. ____ * (if <0 or>10)	X	
11. All samples rec'd within holding time?*	X	
12. VOA vials have zero headspace? * (if contains >5mm headspace)	N/A	
13. Trip Blank received?		

	YES	NO
14. pH check performed by: BH		
15. Metals bottle(s) pH <2?	N/A	
16. Nutrient bottle(s) pH <2? see below		X
17. Cyanide bottle(s) pH >12?	N/A	
18. Sulfide bottle(s) pH >9?		
19. TOC bottle(s) pH <2?		
20. Phenolics bottle(s) pH <2?		
21. Oil & grease bottle(s) pH <2? (checked by analyst)		
22. DRO/418.1 bottle(s) pH <2? (checked by analyst)		
23. Volatiles (VOA) pH <2? (VOA pH checked by analyst)		
24. Herbicides (515) pH <2? (checked by analyst)		
25. Semivolatiles (525) pH <2? (checked by analyst)		
26. Client contacted?		
27. Person contacted		
28. Date contacted		

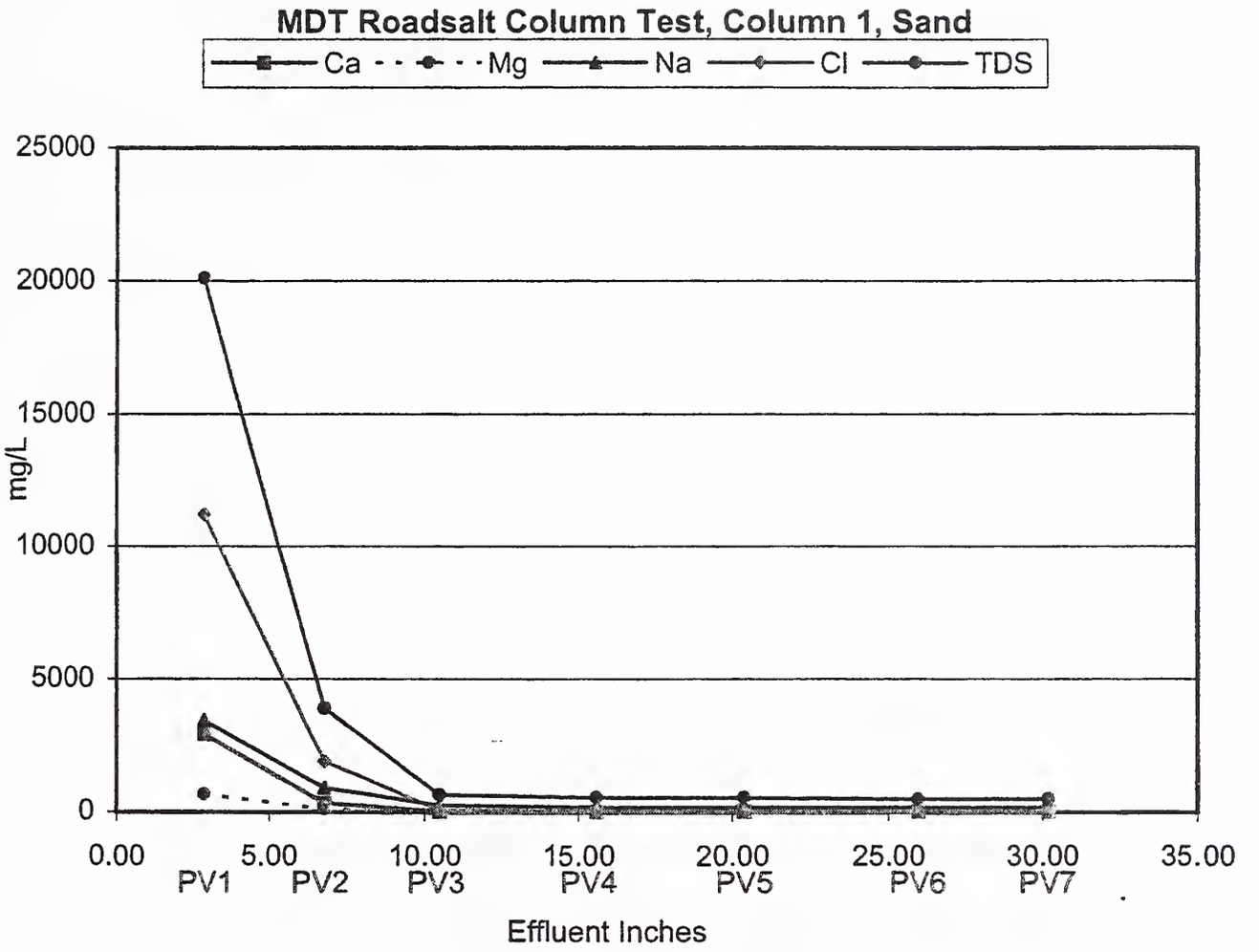
NOTES: **Samples may be affected when not transported at the temperature recommended by the EPA for the test you've selected. Please contact the lab if you have concerns about the temperature of your samples.**

* **Critical item - if marked "NO" contact lab manager.**

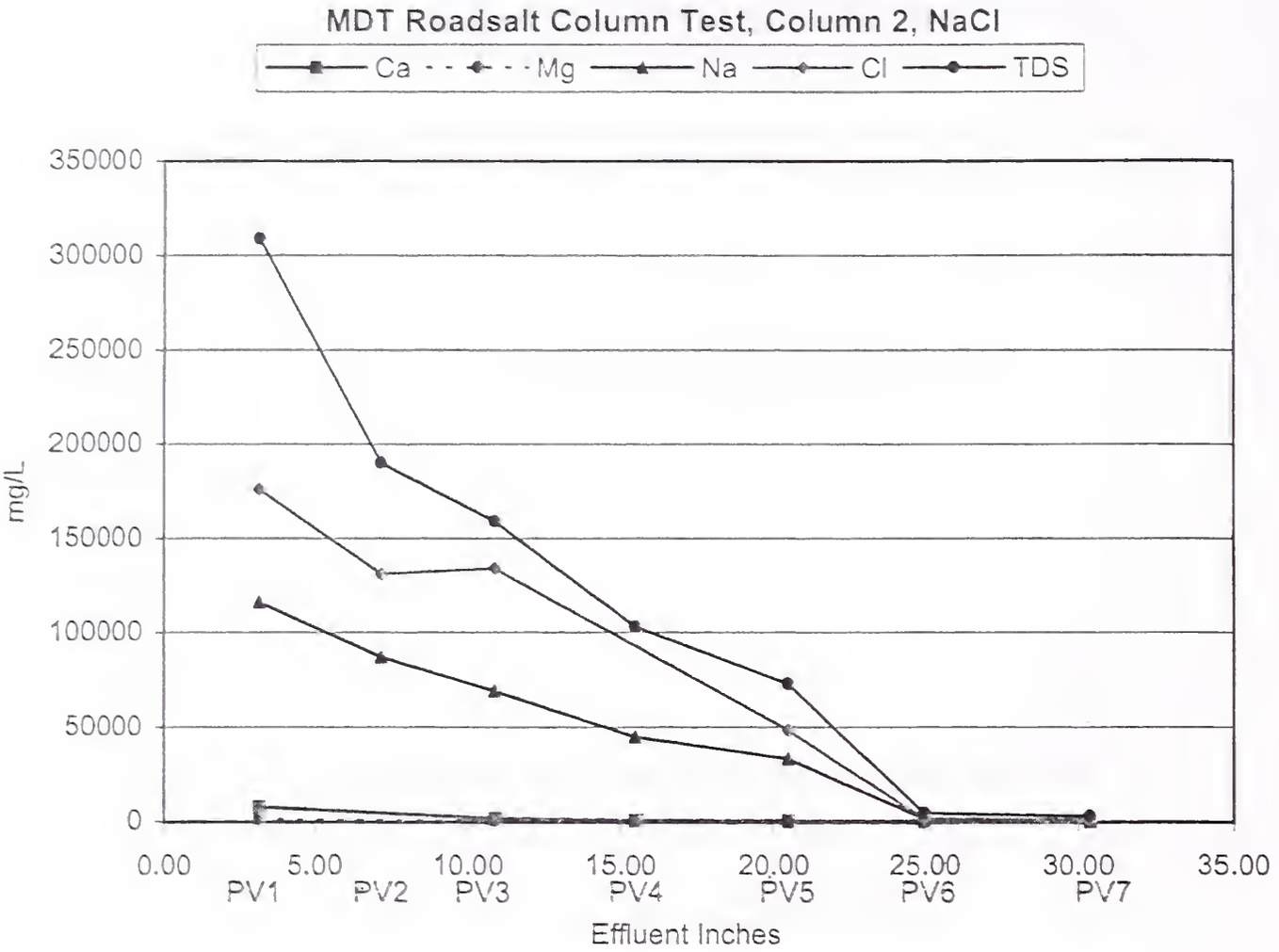
COMMENTS: no packing material in bag w/ soils - lost 2 samples due to breakage (Column #1 and Column #3)
220939 & 941 not preserved - preserved in lab => sample matrix prevents

APPENDIX D

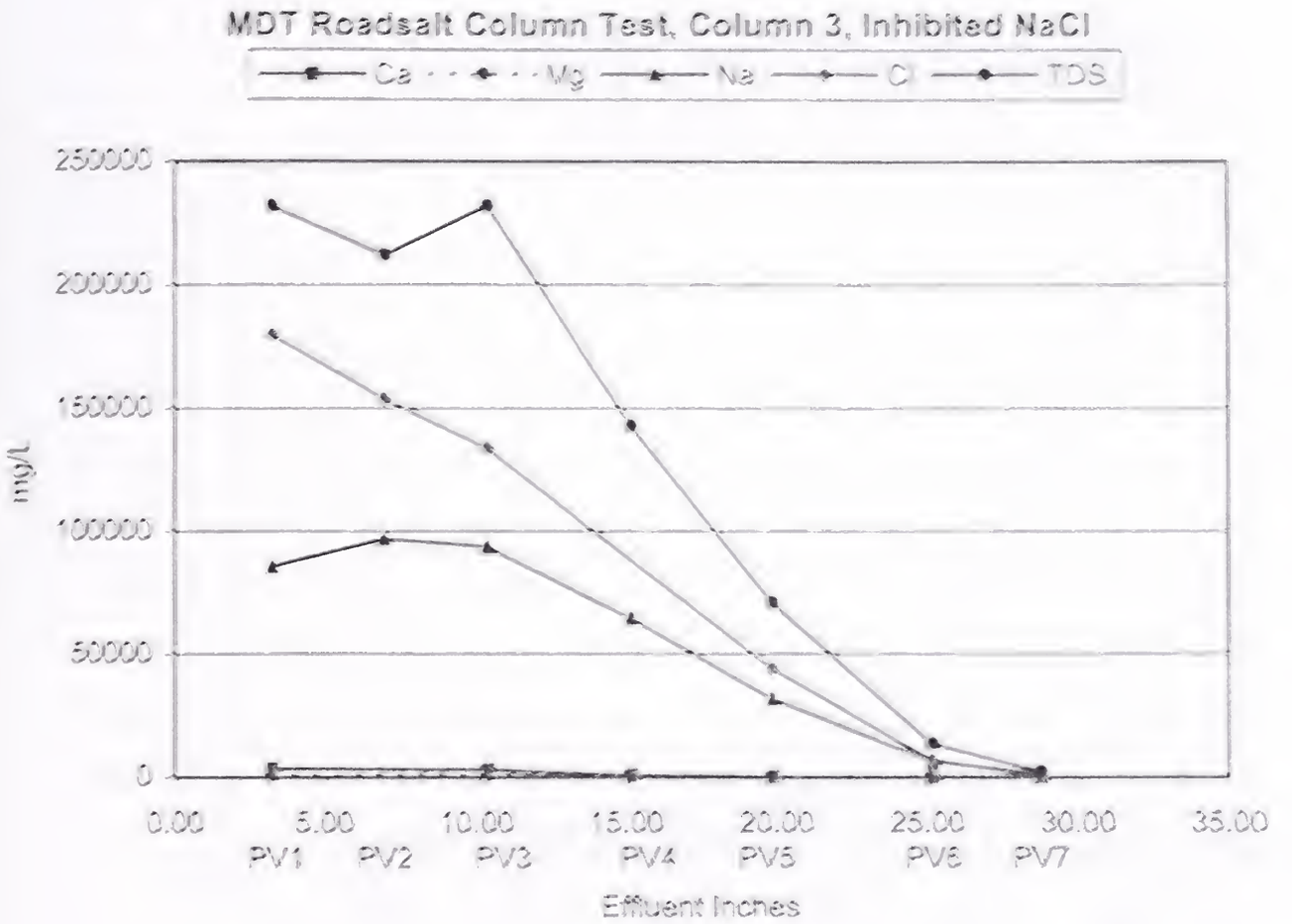
CONCENTRATION VS. PORE VOLUME GRAPHS
COLUMN LEACH EXTRACTION DATA



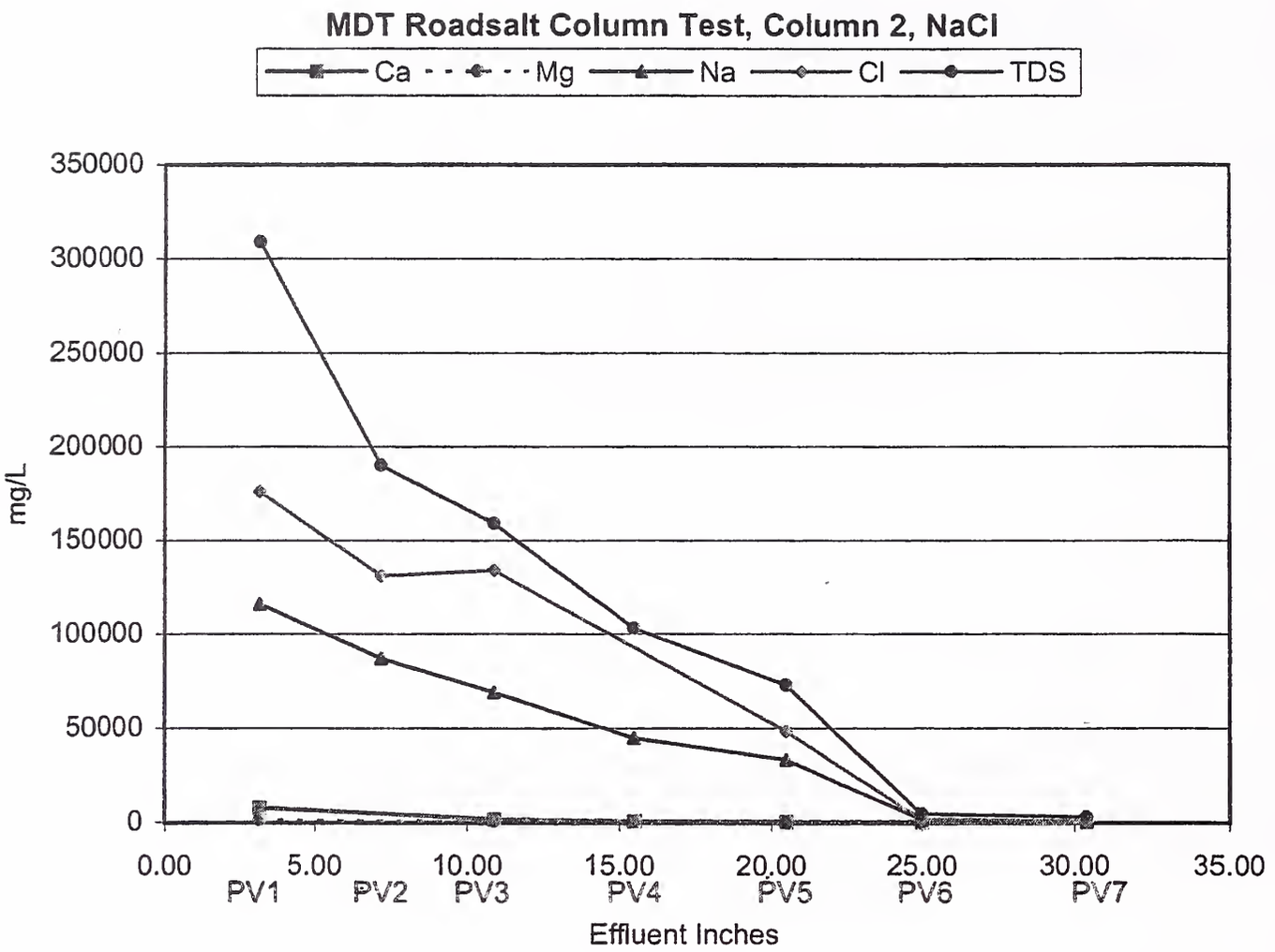
PV ID	Date	Influent (in.)	Effluent (in.)
PV1	12/12/1999	6.10	2.90
PV2	12/20/1999	10.00	6.80
PV3	12/27/1999	13.80	10.50
PV4	12/28/1999	18.50	15.60
PV5	1/11/2000	23.30	20.40
PV6	1/19/2000	29.00	26.00
PV7	2/1/2000	33.80	30.20



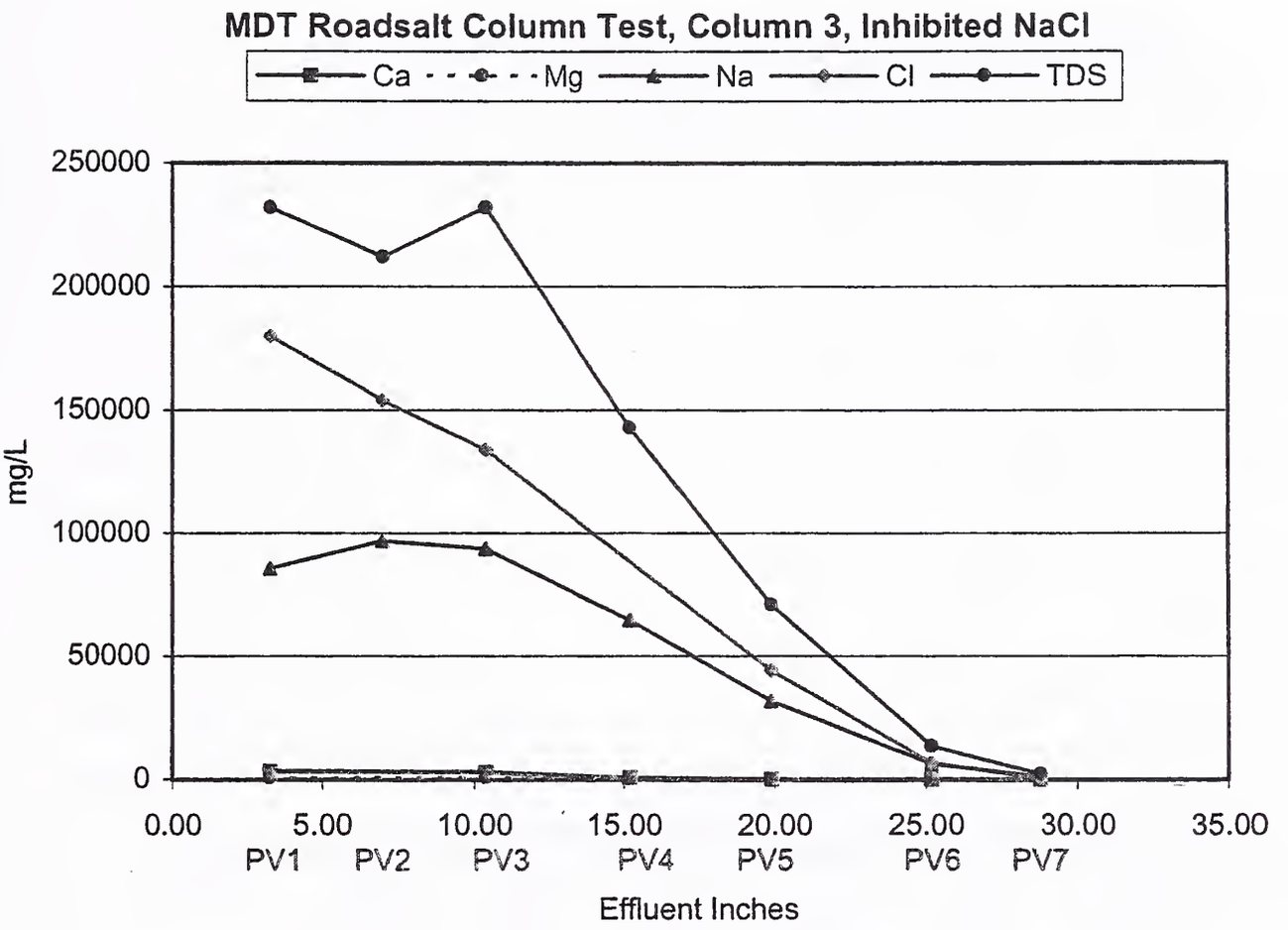
PV ID	Date	Influent (in.)	Effluent (in.)
PV1	12/12/1999	5.90	3.20
PV2	12/20/1999	10.00	7.20
PV3	12/27/1999	14.00	10.90
PV4	12/28/1999	19.10	15.50
PV5	1/11/2000	24.60	20.50
PV6	1/19/2000	29.50	25.00
PV7	2/1/2000	35.20	30.40



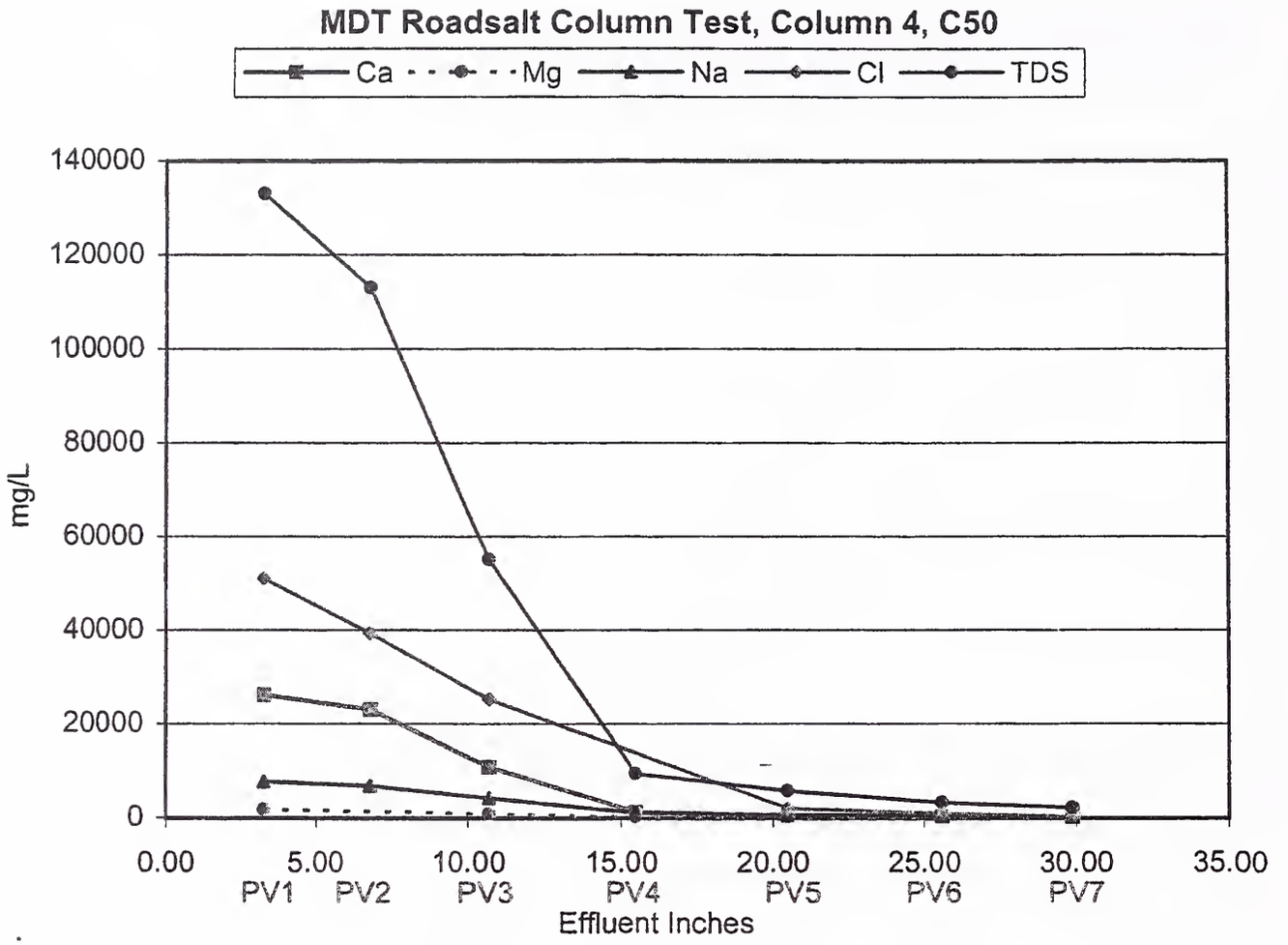
PV ID	Date	Influent (in.)	Effluent (in.)
PV1	12/12/1999	5.90	3.30
PV2	12/20/1999	10.00	7.00
PV3	12/27/1999	13.90	10.40
PV4	12/28/1999	18.40	15.20
PV5	1/11/2000	23.30	19.90
PV6	1/19/2000	28.90	25.20
PV7	2/1/2000	31.90	28.80



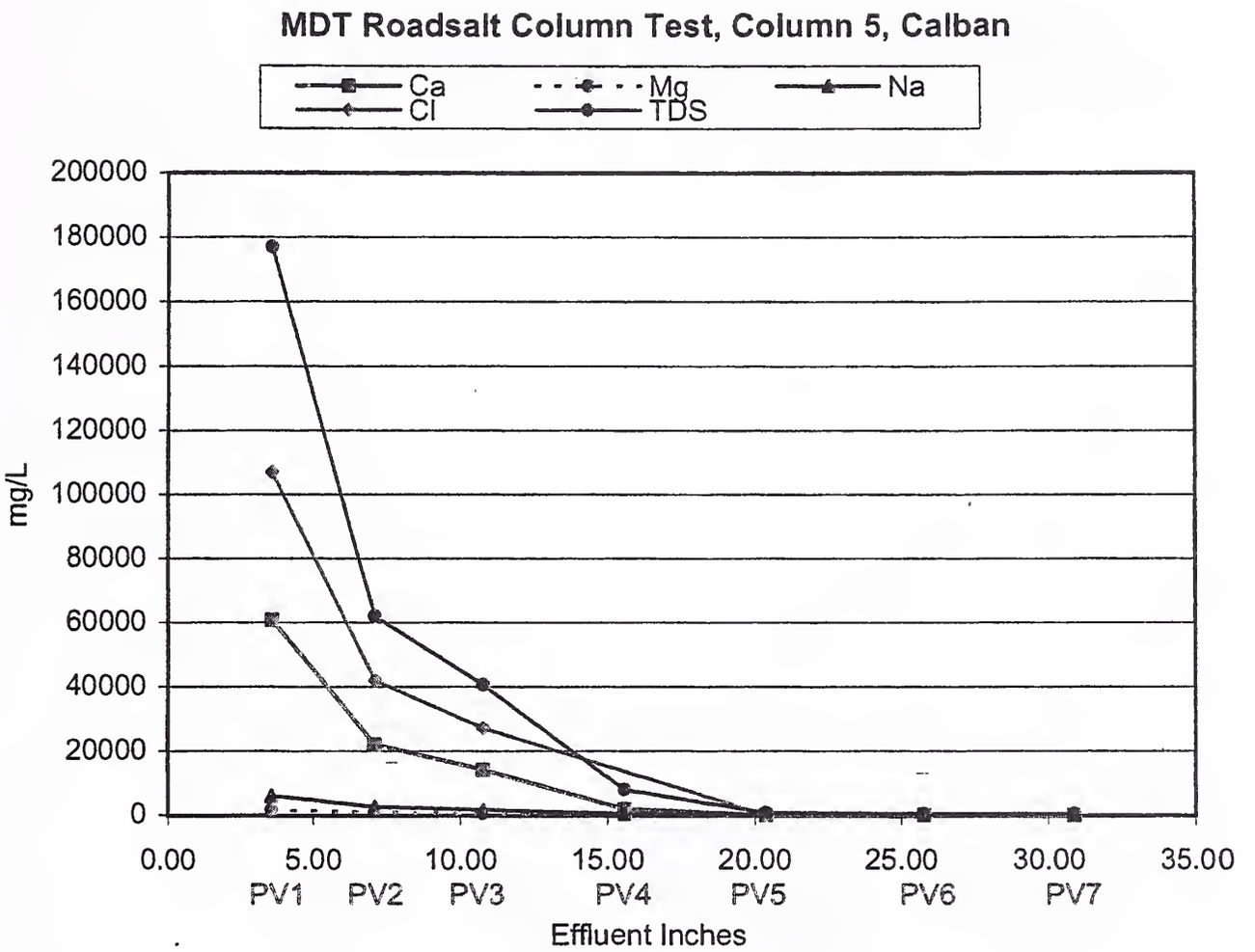
PV ID	Date	Influent (in.)	Effluent (in.)
PV1	12/12/1999	5.90	3.20
PV2	12/20/1999	10.00	7.20
PV3	12/27/1999	14.00	10.90
PV4	12/28/1999	19.10	15.50
PV5	1/11/2000	24.60	20.50
PV6	1/19/2000	29.50	25.00
PV7	2/1/2000	35.20	30.40



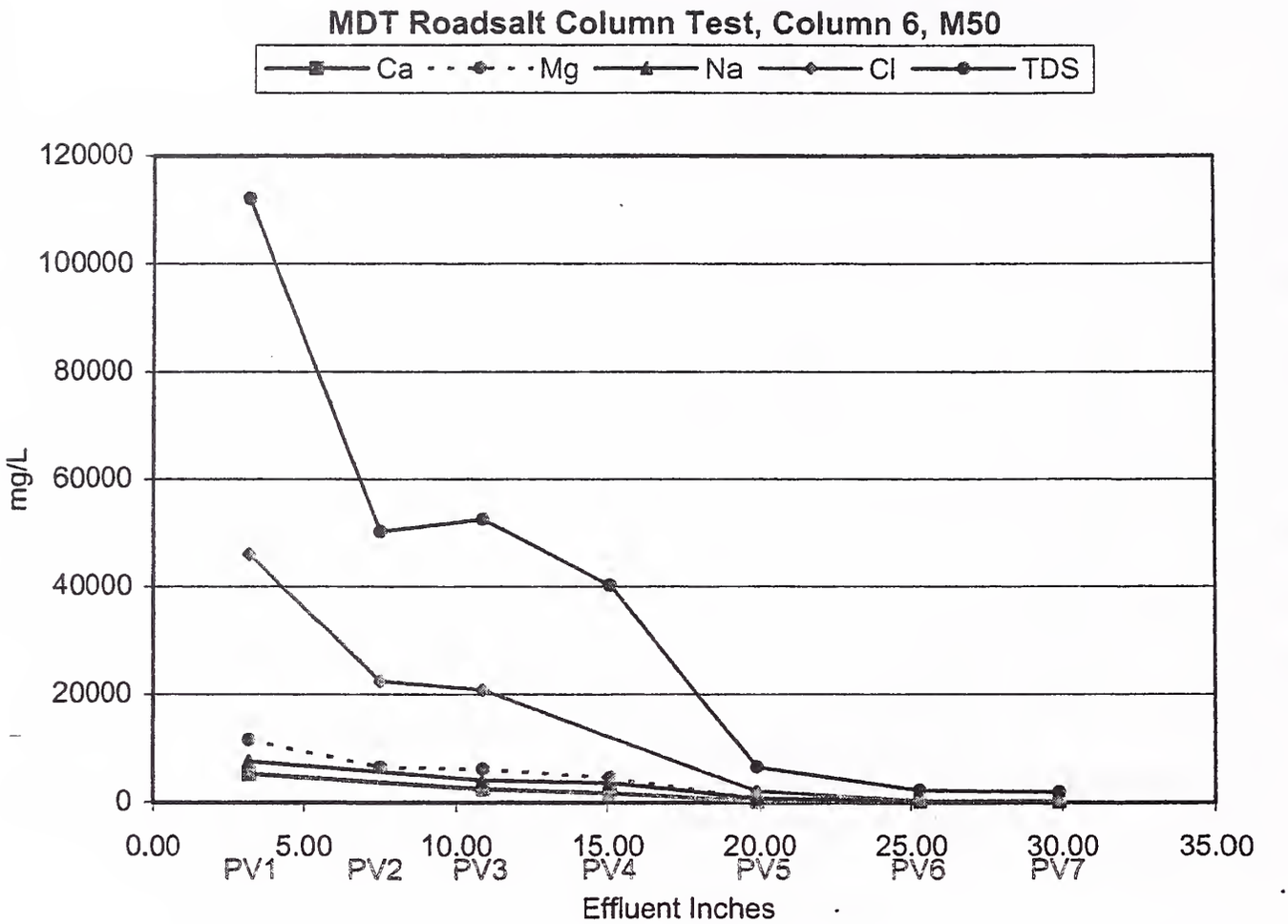
PV ID	Date	Influent (in.)	Effluent (in.)
PV1	12/12/1999	5.90	3.30
PV2	12/20/1999	10.00	7.00
PV3	12/27/1999	13.90	10.40
PV4	12/28/1999	18.40	15.20
PV5	1/11/2000	23.30	19.90
PV6	1/19/2000	28.90	25.20
PV7	2/1/2000	31.90	28.80



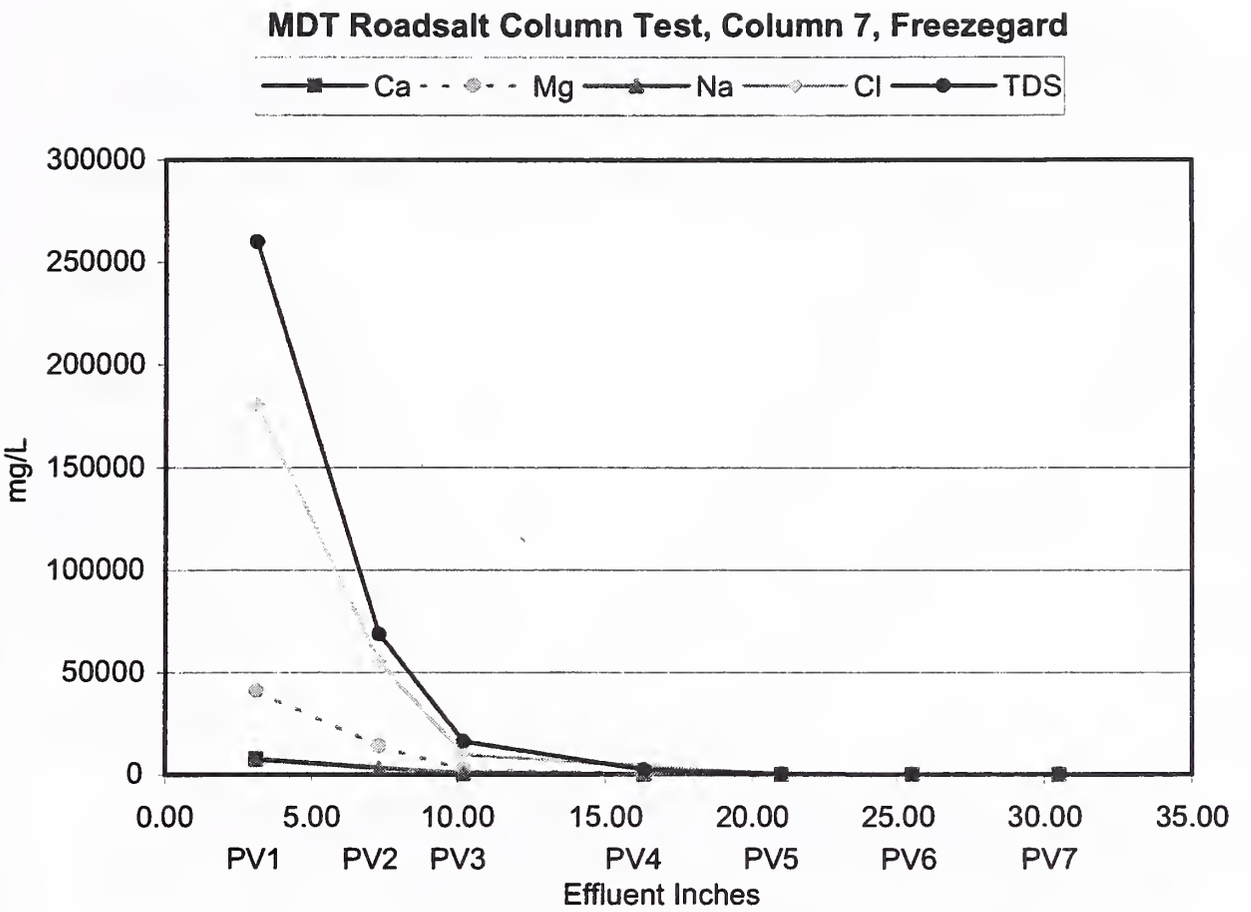
PV ID	Date	Influent (in.)	Effluent (in.)
PV1	12/12/1999	6.10	3.30
PV2	12/20/1999	10.50	6.80
PV3	12/30/1999	15.90	10.70
PV4	12/31/1999	21.50	15.50
PV5	1/14/2000	26.50	20.50
PV6	1/19/2000	32.50	25.60
PV7	2/1/2000	36.90	29.90



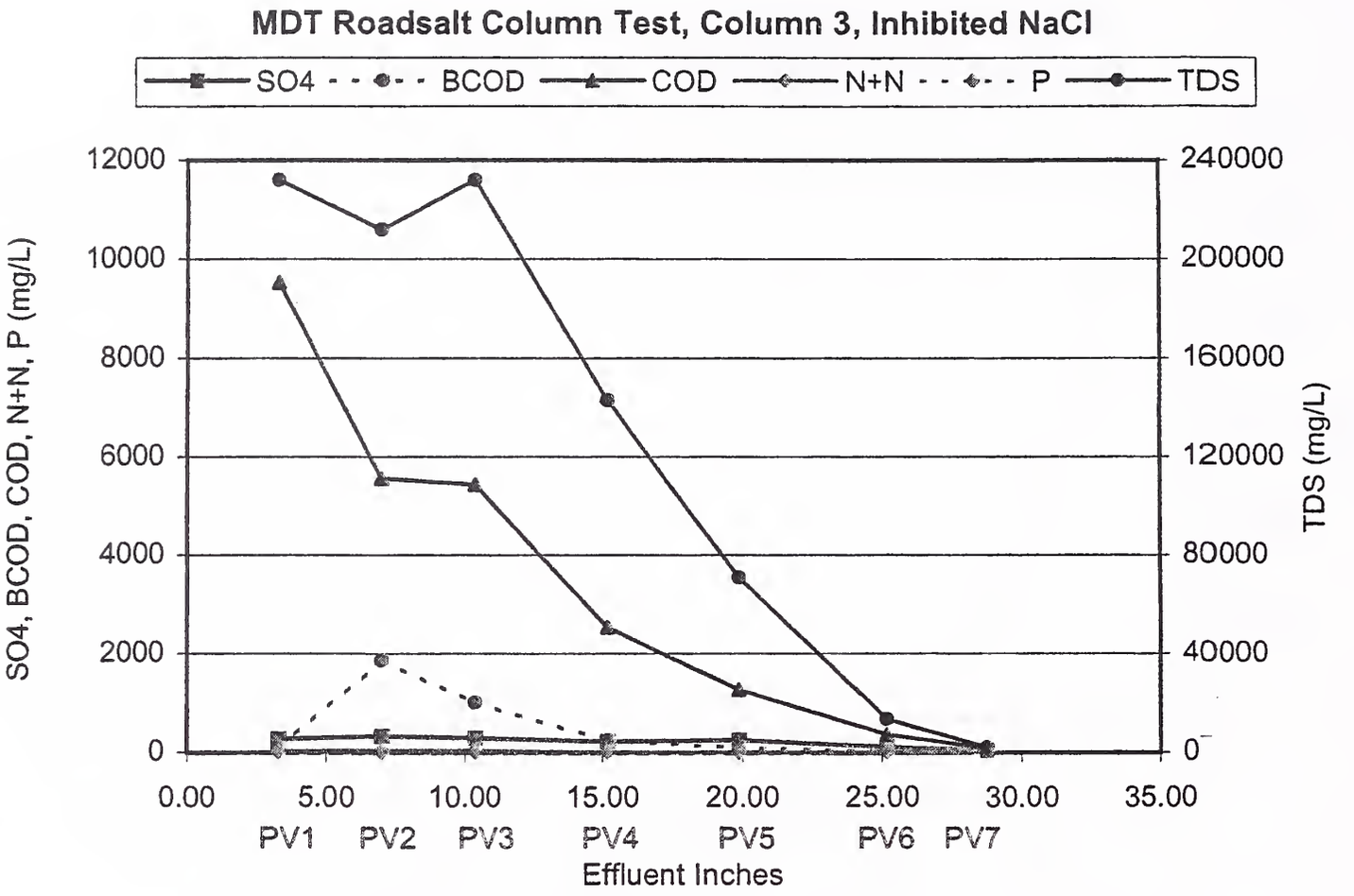
PV ID	Date	Influent (in.)	Effluent (in.)
PV1	12/12/1999	6.10	3.60
PV2	12/20/1999	10.30	7.10
PV3	12/30/1999	15.10	10.80
PV4	12/31/1999	20.80	15.60
PV5	1/14/2000	25.70	20.40
PV6	1/19/2000	30.50	25.80
PV7	2/1/2000	35.80	30.90



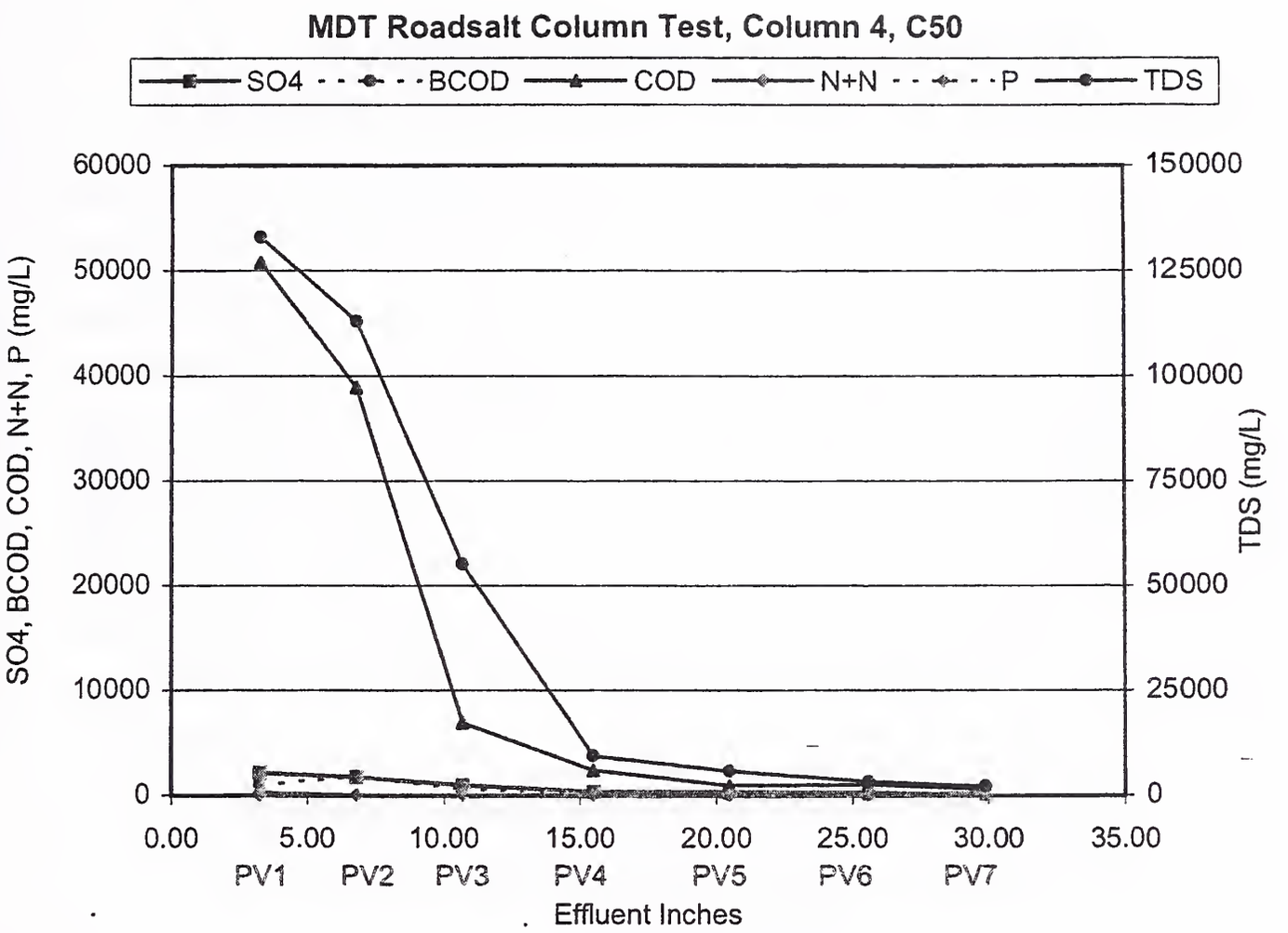
PV ID	Date	Influent (in.)	Effluent (in.)
PV1	12/12/1999	6.40	3.20
PV2	12/20/1999	11.10	7.50
PV3	12/27/1999	14.60	10.90
PV4	12/28/1999	18.80	15.10
PV5	1/13/2000	24.10	19.90
PV6	1/19/2000	29.90	25.30
PV7	2/1/2000	33.40	29.90



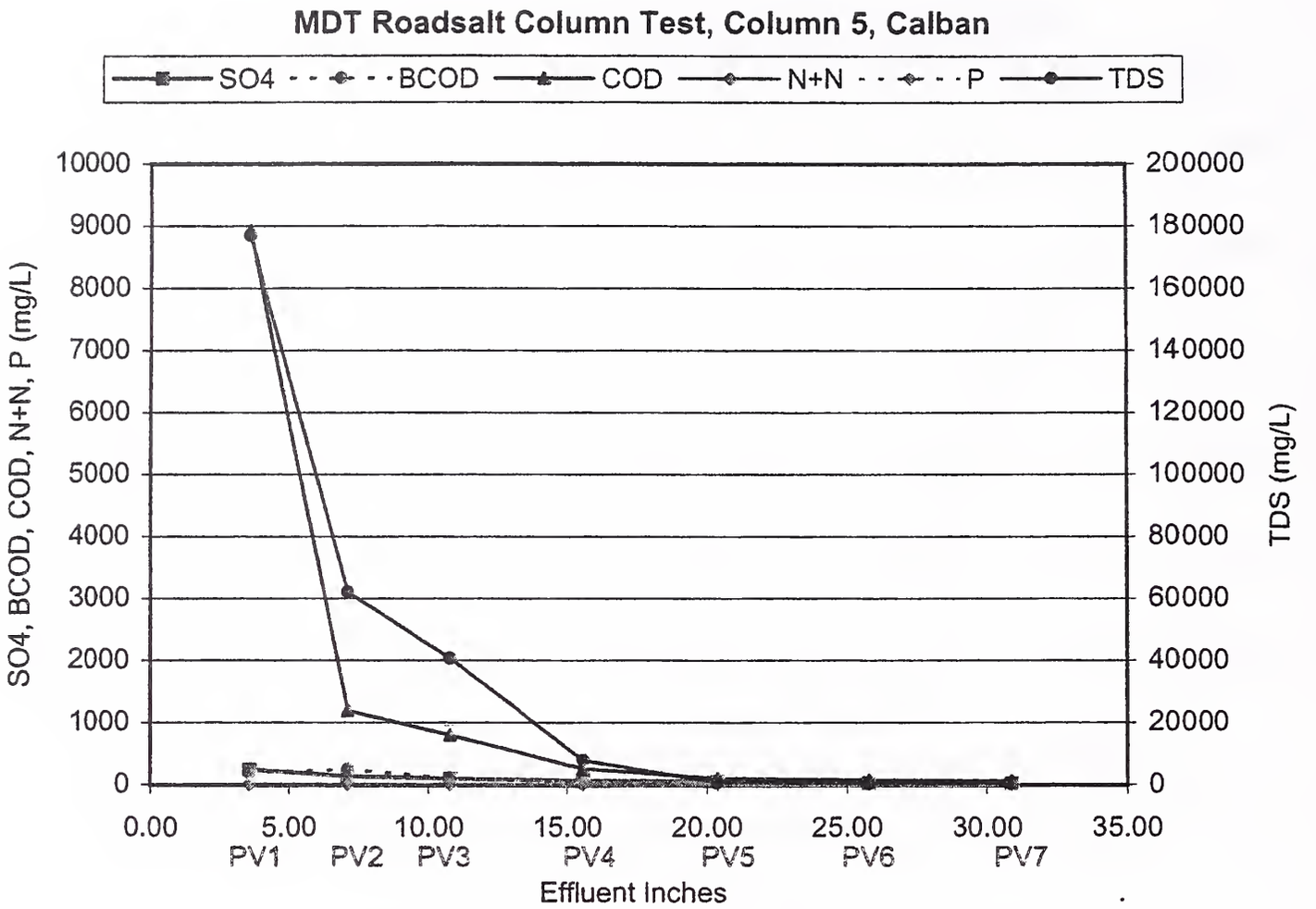
PV ID	Date	Influent (in.)	Effluent (in.)
PV1	12/9/1999	6.30	3.10
PV2	12/20/1999	9.20	7.30
PV3	12/23/1999	12.60	10.20
PV4	12/24/1999	19.10	16.30
PV5	1/13/2000	24.00	21.00
PV6	1/19/2000	28.70	25.50
PV7	2/1/2000	33.60	30.50



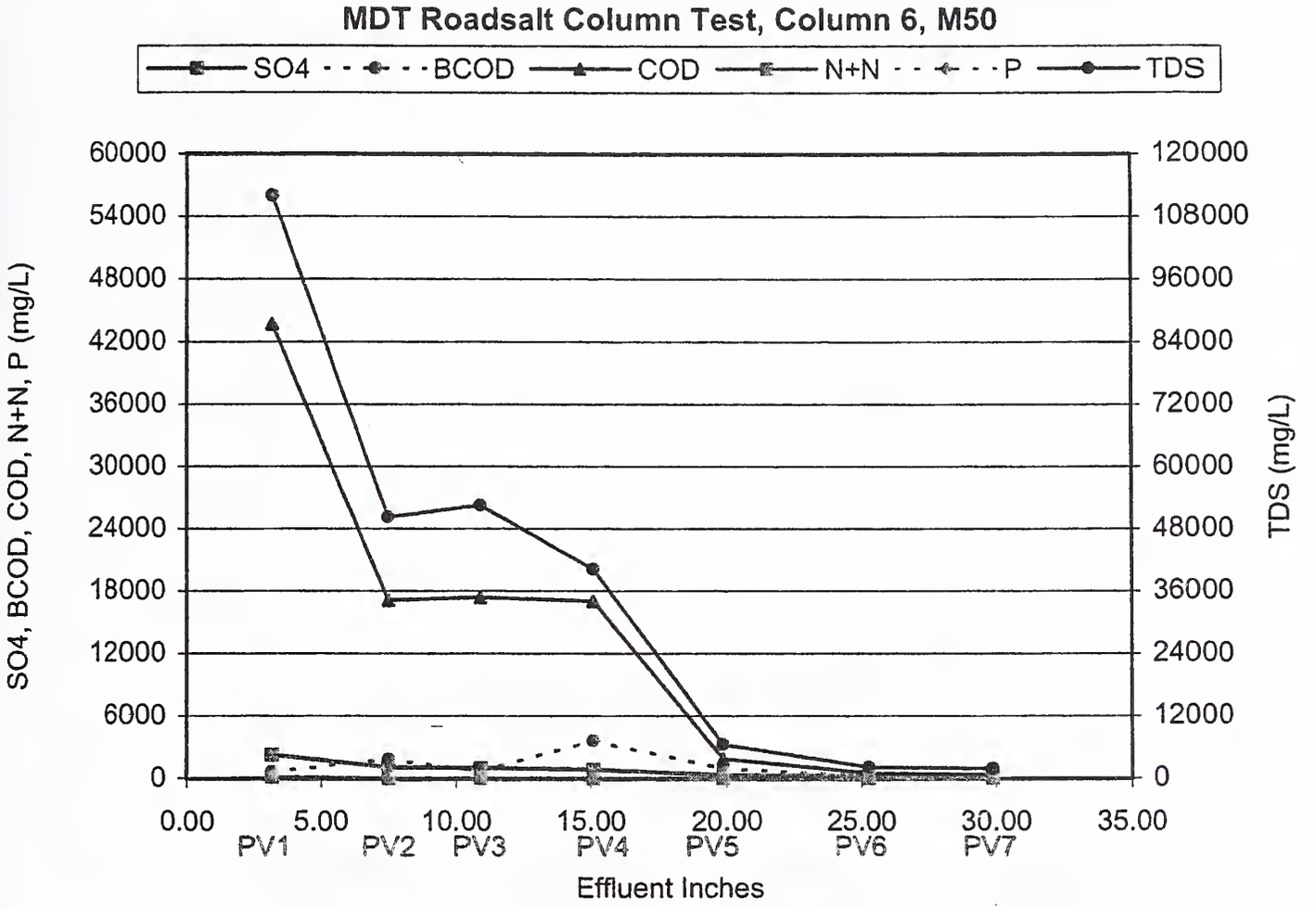
PV ID	Date	Influent (in.)	Effluent (in.)
PV1	12/12/1999	5.90	3.30
PV2	12/20/1999	10.00	7.00
PV3	12/27/1999	13.90	10.40
PV4	12/28/1999	18.40	15.20
PV5	1/11/2000	23.30	19.90
PV6	1/19/2000	28.90	25.20
PV7	2/1/2000	31.90	28.80



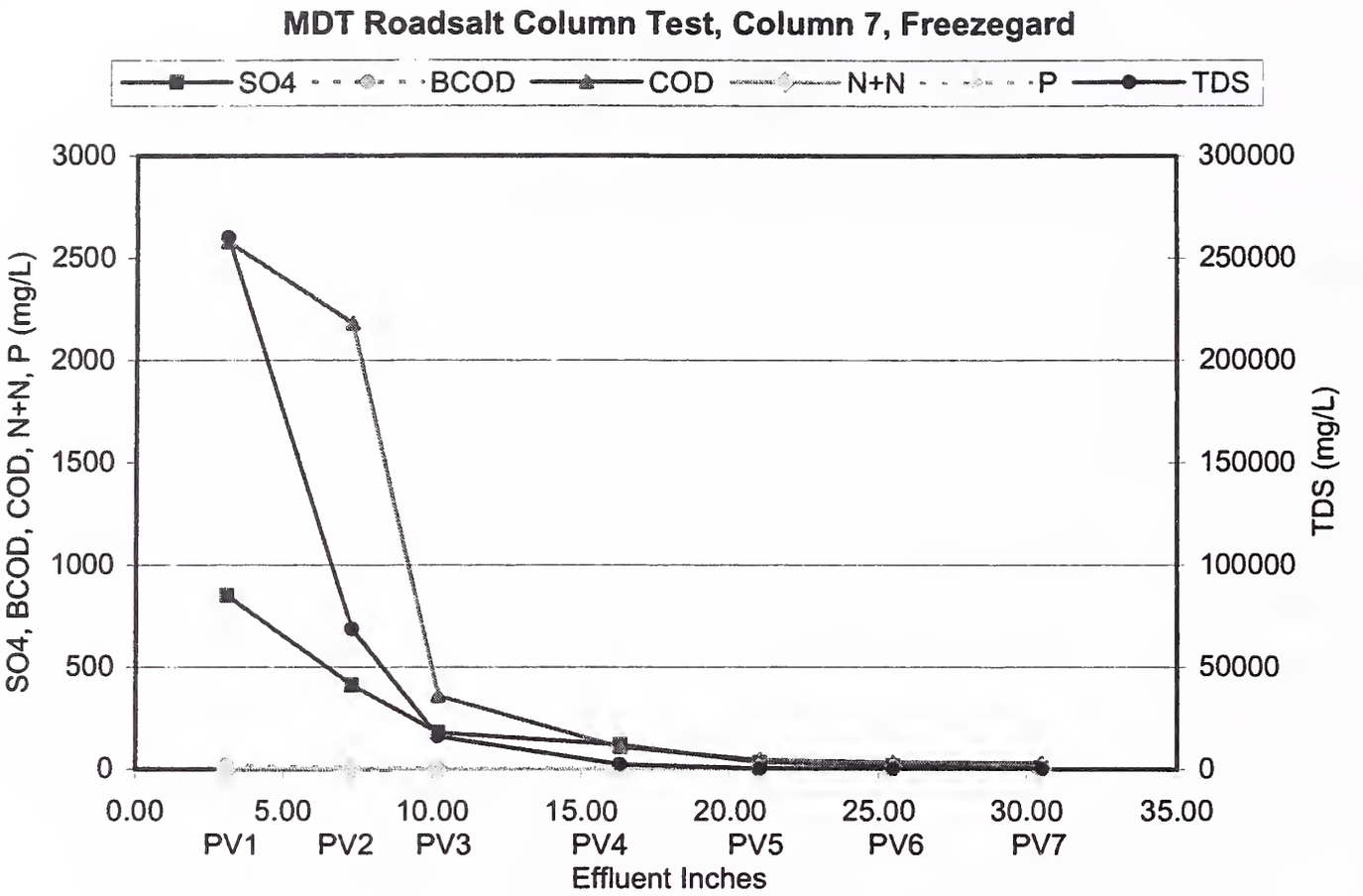
PV ID	Date	Influent (in.)	Effluent (in.)
PV1	12/12/1999	6.10	3.30
PV2	12/20/1999	10.50	6.80
PV3	12/30/1999	15.90	10.70
PV4	12/31/1999	21.50	15.50
PV5	1/14/2000	26.50	20.50
PV6	1/19/2000	32.50	25.60
PV7	2/1/2000	36.90	29.90



PV ID	Date	Influent (in.)	Effluent (in.)
PV1	12/12/1999	6.10	3.60
PV2	12/20/1999	10.30	7.10
PV3	12/30/1999	15.10	10.80
PV4	12/31/1999	20.80	15.60
PV5	1/14/2000	25.70	20.40
PV6	1/19/2000	30.50	25.80
PV7	2/1/2000	35.80	30.90



PV ID	Date	Influent (in.)	Effluent (in.)
PV1	12/12/1999	6.40	3.20
PV2	12/20/1999	11.10	7.50
PV3	12/27/1999	14.60	10.90
PV4	12/28/1999	18.80	15.10
PV5	1/13/2000	24.10	19.90
PV6	1/19/2000	29.90	25.30
PV7	2/1/2000	33.40	29.90



PV ID	Date	Influent (in.)	Effluent (in.)
PV1	12/9/1999	6.30	3.10
PV2	12/20/1999	9.20	7.30
PV3	12/23/1999	12.60	10.20
PV4	12/24/1999	19.10	16.30
PV5	1/13/2000	24.00	21.00
PV6	1/19/2000	28.70	25.50
PV7	2/1/2000	33.60	30.50

APPENDIX E

LABORATORY ANALYTICAL REPORTS
COLUMN TEST LEACHATE SAMPLES

Pore Volume-1

NORTHERN
Analytical Laboratories, Inc.

602 South 25th Street
P O Box 30315
Billings, MT 59107
Telephone: (406) 254-7226
Fax: (406) 254-1389

*Revised: February 8, 2000

REPORT TO: ATTN: TOM TANGEN
MAXIM TECHNOLOGIES, INC.
P O BOX 4699
HELENA MT 59604

DATE: January 27, 2000
JOB NUMBER: 87-911
SHEET: 1 of 9
INVOICE NO.: 25516881

REPORT OF: Water Analysis - MDT Road Salt Columns – 9911852.100

CASE NARRATIVE:

On December 14, 1999, these water samples (laboratory numbers 219878 through 219885) were received in our laboratory for analysis. Tests were conducted in accordance with EPA/600/4-79-020 *"Methods for Chemical Analysis of Water and Wastes"; "Standard Methods for the Examination of Water and Wastewater"*, 18th Edition; SW-846 *"Test Methods for Evaluating Solid Waste"*, 3rd Edition, updates I, II, IIA, IIB, III and Western States Laboratory Proficiency Testing Program, *"Soil & Plant Analytical Methods"*.

The condition of the samples upon receipt at the laboratory is noted on the attached sample receipt checklist Chain of custody documentation is enclosed.

The test results are shown on the following pages.

A <sign indicates the value reported was the practical quantitation limit for this sample using the method described. Concentrations of analyte, if present, below this were not quantifiable.

Footnote: (1) All of the oxygen was consumed in all the dilutions of the sample, therefore a more precise concentration cannot be reported.

*Revised – Organic carbon values.

Reviewed by _____
Denise Jensen
Quality Assurance Coordinator

Attachments: Chain of Custody
Sample Receipt Checklist

caj

As a mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of our clients and authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved pending our written approval. Test results apply specifically to the samples tested only. The entire report shall not be reproduced, except in full, without the written approval of the laboratory. Samples will be disposed of after testing is completed unless other arrangements are agreed to in writing.

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 219878
Sample Name: COLUMN #1, PV #1
Sample Date: 12/12/99
Collected by: TOM TANGEN
Time Sampled: NA
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	85	mg/l	2320B	12/16/99
Alkalinity Carbonate as CO3	0	mg/l	2320B	12/16/99
Alkalinity Total as CaCO3	70	mg/l	2320B	12/16/99
Chloride as Cl	11,200	mg/l	325.3	12/15/99
Sulfate as SO4	48	mg/l	375.3	12/22/99
CATIONS				
Calcium as Ca	2930	mg/l	6010B	12/16/99
Magnesium as Mg	652	mg/l	6010B	12/16/99
Sodium as Na	3440	mg/l	6010B	12/16/99
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/04/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	12/15/99
Chemical Oxygen Demand	1190	mg/l	410.1	12/30/99
pH	7.6	S.U.	150.1	12/14/99
Total Dissolved Solids	20,100	mg/l	160.1	12/15/99
Organic Carbon	446	mg/l	S-9.10 MOD	12/30/99
NUTRIENTS				
Nitrate + Nitrite as N	0.99	mg/l	353.2	12/29/99
Phosphorous Total	0.79	mg/l	365.2	01/05/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 219879
Sample Name: COLUMN #2, PV #1
Sample Date: 12/12/99
Collected by: TOM TANGEN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	13	mg/l	2320B	12/16/99
Alkalinity Carbonate as CO3	0	mg/l	2320B	12/16/99
Alkalinity Total as CaCO3	11	mg/l	2320B	12/16/99
Chloride as Cl	176,000	mg/l	325.3	01/18/00
Sulfate as SO4	199	mg/l	375.3	12/22/99
CATIONS				
Calcium as Ca	7740	mg/l	6010B	12/16/99
Magnesium as Mg	1300	mg/l	6010B	12/16/99
Sodium as Na	116,000	mg/l	6010B	01/19/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/04/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	12/15/99
Chemical Oxygen Demand	4960	mg/l	410.1	12/30/99
pH	6.6	S.U.	150.1	12/14/99
Total Dissolved Solids	309,000	mg/l	160.1	12/17/99
Organic Carbon	1860	mg/l	S-9.10 MOD	12/30/99
NUTRIENTS				
Nitrate + Nitrite as N	0.41	mg/l	353.2	12/29/99
Phosphorous Total	0.53	mg/l	365.2	01/05/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 219880
Sample Name: COLUMN #3, PV #1
Sample Date: 12/12/99
Collected by: TOM TANGEN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	358	mg/l	2320B	12/16/99
Alkalinity Carbonate as CO3	0	mg/l	2320B	12/16/99
Alkalinity Total as CaCO3	293	mg/l	2320B	12/16/99
Chloride as Cl	180,000	mg/l	325.3	01/06/00
Sulfate as SO4	268	mg/l	375.3	12/22/99
CATIONS				
Calcium as Ca	3260	mg/l	6010B	12/16/99
Magnesium as Mg	622	mg/l	6010B	12/16/99
Sodium as Na	85,700	mg/l	6010B	12/16/99
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/05/00
INORGANICS				
Biochemical Oxygen Demand	>83 (1)	mg/l	405.1	12/15/99
Chemical Oxygen Demand	9530	mg/l	410.1	12/30/99
pH	7.1	S.U.	150.1	12/14/99
Total Dissolved Solids	232,000	mg/l	160.1	01/27/00
Organic Carbon	3570	mg/l	S-9.10 MOD	12/30/99
NUTRIENTS				
Nitrate + Nitrite as N	30	mg/l	353.2	12/29/99
Phosphorous Total	1.05	mg/l	365.2	01/05/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 219881
Sample Name: COLUMN #4, PV #1
Sample Date: 12/12/99
Collected by: TOM TANGEN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	3210	mg/l	2320B	12/16/99
Alkalinity Carbonate as CO3	0	mg/l	2320B	12/16/99
Alkalinity Total as CaCO3	2630	mg/l	2320B	12/16/99
Chloride as Cl	51,000	mg/l	325.3	01/18/00
Sulfate as SO4	2100	mg/l	375.3	12/22/99
CATIONS				
Calcium as Ca	26,100	mg/l	6010B	01/07/00
Magnesium as Mg	1720	mg/l	6010B	01/07/00
Sodium as Na	7720	mg/l	6010B	01/07/00
CORROSIVITY				
Steel Coupon Index	3	mmpy	1110	01/05/00
INORGANICS				
Biochemical Oxygen Demand	>970 (1)	mg/l	405.1	12/15/99
Chemical Oxygen Demand	50,800	mg/l	410.1	12/30/99
pH	6.3	S.U.	150.1	12/14/99
Total Dissolved Solids	133,000	mg/l	160.1	12/15/99
Organic Carbon	19,000	mg/l	S-9.10 MOD	12/30/99
NUTRIENTS				
Nitrate + Nitrite as N	250	mg/l	353.2	12/29/99
Phosphorous Total	8.40	mg/l	365.2	01/05/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 219882
Sample Name: COLUMN #5, PV #1
Sample Date: 12/12/99
Collected by: TOM TANGEN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	265	mg/l	2320B	12/16/99
Alkalinity Carbonate as CO3	0	mg/l	2320B	12/16/99
Alkalinity Total as CaCO3	217	mg/l	2320B	12/16/99
Chloride as Cl	107,000	mg/l	325.3	01/18/00
Sulfate as SO4	239	mg/l	375.3	12/22/99
CATIONS				
Calcium as Ca	60,900	mg/l	6010B	01/07/00
Magnesium as Mg	1580	mg/l	6010B	01/07/00
Sodium as Na	6090	mg/l	6010B	01/07/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/06/00
INORGANICS				
Biochemical Oxygen Demand	>190 (1)	mg/l	405.1	12/15/99
Chemical Oxygen Demand	8930	mg/l	410.1	12/30/99
pH	6.2	S.U.	150.1	12/14/99
Total Dissolved Solids	177,000	mg/l	160.1	12/17/99
Organic Carbon	3350	mg/l	S-9.10 MOD	12/30/99
NUTRIENTS				
Nitrate + Nitrite as N	1.2	mg/l	353.2	12/29/99
Phosphorous Total	5.96	mg/l	365.2	01/05/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 219883
Sample Name: COLUMN #6, PV #1
Sample Date: 12/12/99
Collected by: TOM TANGEN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	5220	mg/l	2320B	12/16/99
Alkalinity Carbonate as CO3	0	mg/l	2320B	12/16/99
Alkalinity Total as CaCO3	4280	mg/l	2320B	12/16/99
Chloride as Cl	46,000	mg/l	325.3	01/18/00
Sulfate as SO4	2250	mg/l	375.3	12/22/99
CATIONS				
Calcium as Ca	5200	mg/l	6010B	01/07/00
Magnesium as Mg	11,500	mg/l	6010B	01/07/00
Sodium as Na	7550	mg/l	6010B	01/07/00
CORROSIVITY				
Steel Coupon Index	3	mmpy	1110	01/06/00
INORGANICS				
Biochemical Oxygen Demand	>620 (1)	mg/l	405.1	12/15/99
Chemical Oxygen Demand	43,700	mg/l	410.1	12/30/99
pH	6.8	S.U.	150.1	12/14/99
Total Dissolved Solids	112,000	mg/l	160.1	12/15/99
Organic Carbon	16,400	mg/l	S-9.10 MOD	12/30/99
NUTRIENTS				
Nitrate + Nitrite as N	110	mg/l	353.2	12/29/99
Phosphorous Total	12.7	mg/l	365.2	01/05/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 219884
Sample Name: COLUMN #7, PV #1
Sample Date: 12/09/99
Collected by: TOM TANGEN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	311	mg/l	2320B	12/16/99
Alkalinity Carbonate as CO3	0	mg/l	2320B	12/16/99
Alkalinity Total as CaCO3	255	mg/l	2320B	12/16/99
Chloride as Cl	181,000	mg/l	325.3	12/15/99
Sulfate as SO4	853	mg/l	375.3	12/22/99
CATIONS				
Calcium as Ca	7840	mg/l	6010B	12/16/99
Magnesium as Mg	41,000	mg/l	6010B	12/16/99
Sodium as Na	7470	mg/l	6010B	12/16/99
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/06/00
INORGANICS				
Biochemical Oxygen Demand	20	mg/l	405.1	12/15/99
Chemical Oxygen Demand	2580	mg/l	410.1	12/30/99
pH	6.5	S.U.	150.1	12/14/99
Total Dissolved Solids	260,000	mg/l	160.1	12/17/99
Organic Carbon	968	mg/l	S-9.10 MOD	12/30/99
NUTRIENTS				
Nitrate + Nitrite as N	2.0	mg/l	353.2	12/29/99
Phosphorous Total	5.95	mg/l	365.2	01/05/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 219885
Sample Name: DI WATER, INFLUENT
Sample Date: 12/13/99
Collected by: TOM TANGEN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	13	mg/l	2320B	12/16/99
Alkalinity Carbonate as CO3	0	mg/l	2320B	12/16/99
Alkalinity Total as CaCO3	11	mg/l	2320B	12/16/99
Chloride as Cl	<1	mg/l	325.3	12/15/99
Sulfate as SO4	<5	mg/l	375.3	12/22/99
CATIONS				
Calcium as Ca	<1	mg/l	6010B	12/16/99
Magnesium as Mg	<1	mg/l	6010B	12/16/99
Sodium as Na	<1	mg/l	6010B	12/16/99
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/10/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	12/15/99
Chemical Oxygen Demand	<5	mg/l	410.2	12/30/99
pH	6.6	S.U.	150.1	12/14/99
Total Dissolved Solids	1220	mg/l	160.1	12/15/99
Organic Carbon	<2	mg/l	S-9.10 MOD	12/30/99
NUTRIENTS				
Nitrate + Nitrite as N	<0.10	mg/l	353.2	12/29/99
Phosphorous Total	<0.02	mg/l	365.2	01/05/00

mmpy – millimeters of corrosion of a steel coupon per year

Pore Volume-2

NORTHERN
Analytical Laboratories, Inc.

RECEIVED
FEB 09 2000
MAXIM TECHNOLOGIES
HELENA, MT

602 South 25th Street
P O Box 30315
Billings, MT 59107
Telephone: (406) 254-7226
Fax: (406) 254-1389

REPORT TO: ATTN: TOM TANGEN
MAXIM TECHNOLOGIES, INC.
P O BOX 4699
HELENA MT 59604

DATE: February 8, 2000
JOB NUMBER: 87-911
SHEET: 1 of 8
INVOICE NO.: 25516984

REPORT OF: Water Analysis - MDT Road Salt Columns – 9911852.100

CASE NARRATIVE:

On December 28, 1999, these water samples (laboratory numbers 220936 through 220942) were received in our laboratory for analysis. Tests were conducted in accordance with EPA/600/4-79-020 *"Methods for Chemical Analysis of Water and Wastes"*; *"Standard Methods for the Examination of Water and Wastewater"*, 18th Edition; SW-846 *"Test Methods for Evaluating Solid Waste"*, 3rd Edition, updates I, II, IIA, IIB, III and Western States Laboratory Proficiency Testing Program, *"Soil & Plant Analytical Methods"*.

The condition of the samples upon receipt at the laboratory is noted on the attached sample receipt checklist Chain of custody documentation is enclosed.

The test results are shown on the following pages.

A <sign indicates the value reported was the practical quantitation limit for this sample using the method described. Concentrations of analyte, if present, below this were not quantifiable.

Footnote: (1) All of the oxygen was consumed in all the dilutions of the sample, therefore a more precise concentration cannot be reported.
(2) A higher quantitation limit was required as the sample had to be diluted prior to analysis to reduce color interference.

Reviewed by _____
Kathleen A. Smit - Laboratory Manager

Attachments: Chain of Custody
Sample Receipt Checklist

caj

As a mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of our clients and authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved pending our written approval. Test results apply specifically to the samples tested only. The entire report shall not be reproduced, except in full, without the written approval of the laboratory. Samples will be disposed of after testing is completed unless other arrangements are agreed to in writing.

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 220936
Sample Name: COL #1 PV-2
Sample Date: 12/20/99
Collected by: TOM TANGEN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	258	mg/l	2320B	01/04/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/04/99
Alkalinity Total as CaCO3	211	mg/l	2320B	01/04/00
Chloride as Cl	1890	mg/l	325.3	12/30/99
Sulfate as SO4	80	mg/l	375.3	01/06/00
CATIONS				
Calcium as Ca	310	mg/l	6010B	01/07/00
Magnesium as Mg	<100	mg/l	6010B	01/07/00
Sodium as Na	890	mg/l	6010B	01/07/00
CORROSIVITY				
Steel Coupon Index	1	mmpy	1110	01/12/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	12/29/99
Chemical Oxygen Demand	992	mg/l	410.1	12/30/99
pH	8.1	S.U.	150.1	12/28/99
Total Dissolved Solids	3890	mg/l	160.1	12/28/99
Organic Carbon	372	mg/l	S-9.10 MOD	12/30/99
NUTRIENTS				
Nitrate + Nitrite as N	0.40	mg/l	353.2	12/29/99
Phosphorous Total	0.41	mg/l	365.2	01/05/00

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 220937
Sample Name: COL #2 PV-2
Sample Date: 12/20/99
Collected by: TOM TANGEN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	106	mg/l	2320B	01/04/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/04/99
Alkalinity Total as CaCO3	87	mg/l	2320B	01/04/00
Chloride as Cl	131,000	mg/l	325.3	01/06/00
Sulfate as SO4	165	mg/l	375.3	01/06/00
CATIONS				
Sodium as Na	87,000	mg/l	6010B	01/07/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/12/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	12/29/99
Chemical Oxygen Demand	1980	mg/l	410.1	12/30/99
pH	7.5	S.U.	150.1	12/28/99
Total Dissolved Solids	190,000	mg/l	160.1	12/28/99
Organic Carbon	742	mg/l	S-9.10 MOD	12/30/99
NUTRIENTS				
Nitrate + Nitrite as N	0.16	mg/l	353.2	12/29/99
Phosphorous Total	0.79	mg/l	365.2	01/05/00

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 220938
Sample Name: COL #3 PV-2
Sample Date: 12/20/99
Collected by: TOM TANGEN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	337	mg/l	2320B	01/04/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/04/99
Alkalinity Total as CaCO3	276	mg/l	2320B	01/04/00
Chloride as Cl	154,000	mg/l	325.3	01/06/00
Sulfate as SO4	330	mg/l	375.3	01/06/00
CATIONS				
Sodium as Na	96,900	mg/l	6010B	01/07/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/13/00
INORGANICS				
Biochemical Oxygen Demand	1860	mg/l	405.1	12/29/99
Chemical Oxygen Demand	5560	mg/l	410.1	12/30/99
pH	7.0	S.U.	150.1	12/28/99
Total Dissolved Solids	212,000	mg/l	160.1	12/28/99
Organic Carbon	2100	mg/l	S-9.10 MOD	12/30/99
NUTRIENTS				
Nitrate + Nitrite as N	34	mg/l	353.2	12/29/99
Phosphorous Total	2.39	mg/l	365.2	01/05/00

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 220939
Sample Name: COL #4 PV-2
Sample Date: 12/20/99
Collected by: TOM TANGEN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	3260	mg/l	2320B	01/04/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/04/99
Alkalinity Total as CaCO3	2670	mg/l	2320B	01/04/00
Chloride as Cl	39,300	mg/l	325.3	12/30/99
Sulfate as SO4	1700	mg/l	375.3	01/06/00
CATIONS				
Calcium as Ca	23,000	mg/l	6010B	01/07/00
Sodium as Na	6730	mg/l	6010B	01/07/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/13/00
INORGANICS				
Biochemical Oxygen Demand	>1800 (1)	mg/l	405.1	12/29/99
Chemical Oxygen Demand	38,900	mg/l	410.1	12/30/99
pH	6.7	S.U.	150.1	12/28/99
Total Dissolved Solids	113,000	mg/l	160.1	12/28/99
Organic Carbon	14,600	mg/l	S-9.10 MOD	12/30/99
NUTRIENTS				
Nitrate + Nitrite as N	<2.5 (2)	mg/l	353.2	12/29/99
Phosphorous Total	9.21	mg/l	365.2	01/05/00

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 220940
Sample Name: COL #5 PV-2
Sample Date: 12/20/99
Collected by: TOM TANGEN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	186	mg/l	2320B	01/04/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/04/99
Alkalinity Total as CaCO3	152	mg/l	2320B	01/04/00
Chloride as Cl	42,000	mg/l	325.3	12/30/99
Sulfate as SO4	128	mg/l	375.3	01/06/00
CATIONS				
Calcium as Ca	22,100	mg/l	6010B	01/07/00
Sodium as Na	2640	mg/l	6010B	01/07/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/17/00
INORGANICS				
Biochemical Oxygen Demand	238	mg/l	405.1	12/29/99
Chemical Oxygen Demand	1190	mg/l	410.1	12/30/99
pH	6.6	S.U.	150.1	12/28/99
Total Dissolved Solids	62,000	mg/l	160.1	12/28/99
Organic Carbon	446	mg/l	S-9.10 MOD	12/30/99
NUTRIENTS				
Nitrate + Nitrite as N	<0.10	mg/l	353.2	12/29/99
Phosphorous Total	1.60	mg/l	365.2	01/05/00

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 220941
Sample Name: COL #6 PV-2
Sample Date: 12/20/99
Collected by: TOM TANGEN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	4050	mg/l	2320B	01/04/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/04/99
Alkalinity Total as CaCO3	3320	mg/l	2320B	01/04/00
Chloride as Cl	22,400	mg/l	325.3	01/06/00
Sulfate as SO4	1030	mg/l	375.3	01/06/00
CATIONS				
Magnesium as Mg	6420	mg/l	6010B	01/07/00
CORROSIVITY				
Steel Coupon Index	3	mmpy	1110	01/17/00
INORGANICS				
Biochemical Oxygen Demand	>1800 (1)	mg/l	405.1	12/29/99
Chemical Oxygen Demand	17,100	mg/l	410.1	12/30/99
pH	7.2	S.U.	150.1	12/28/99
Total Dissolved Solids	50,200	mg/l	160.1	12/28/99
Organic Carbon	6410	mg/l	S-9.10 MOD	12/30/99
NUTRIENTS				
Nitrate + Nitrite as N	<2.5 (2)	mg/l	353.2	12/29/99
Phosphorous Total	5.39	mg/l	365.2	01/05/00

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 220942
Sample Name: COL #7 PV-2
Sample Date: 12/20/99
Collected by: TOM TANGEN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	325	mg/l	2320B	01/04/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/04/99
Alkalinity Total as CaCO3	266	mg/l	2320B	01/04/00
Chloride as Cl	55,100	mg/l	325.3	12/30/99
Sulfate as SO4	412	mg/l	375.3	01/06/00
CATIONS				
Magnesium as Mg	14,000	mg/l	6010B	01/07/00
Sodium as Na	3290	mg/l	6010B	01/07/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/18/00
INORGANICS				
Biochemical Oxygen Demand	<8	mg/l	405.1	12/29/99
Chemical Oxygen Demand	2180	mg/l	410.1	12/30/99
pH	7.5	S.U.	150.1	12/28/99
Total Dissolved Solids	68,800	mg/l	160.1	12/28/99
Organic Carbon	818	mg/l	S-9.10 MOD	12/30/99
NUTRIENTS				
Nitrate + Nitrite as N	1.1	mg/l	353.2	12/29/99
Phosphorous Total	0.74	mg/l	365.2	01/05/00

Pore Volume-3

NORTHERN
Analytical Laboratories, Inc.

602 South 25th Street
P O Box 30315
Billings, MT 59107
Telephone: (406) 254-7226
Fax: (406) 254-1389

REPORT TO: ATTN: TOM TANGEN
MAXIM TECHNOLOGIES, INC.
P O BOX 4699
HELENA MT 59604

DATE: February 10, 2000
JOB NUMBER: 87-911
SHEET: 1 of 12
INVOICE NO.: 25517043

REPORT OF: Water & Soil Analysis - MDT Column Tests – 9911852.100

CASE NARRATIVE:

On January 5, 2000, these water and soil samples (laboratory numbers 221022 through 221030) were received in our laboratory for analysis. Tests were conducted in accordance with EPA/600/4-79-020 *"Methods for Chemical Analysis of Water and Wastes"*; *"Standard Methods for the Examination of Water and Wastewater"*, 18th Edition; SW-846 *"Test Methods for Evaluating Solid Waste"*, 3rd Edition, updates I, II, IIA, IIB, III and Western States Laboratory Proficiency Testing Program, *"Soil & Plant Analytical Methods"*.

The condition of the samples upon receipt at the laboratory is noted on the attached sample receipt checklist Chain of custody documentation is enclosed.

The test results are shown on the following pages.

A <sign indicates the value reported was the practical quantitation limit for this sample using the method described. Concentrations of analyte, if present, below this were not quantifiable.

Reviewed by _____
Kathleen A. Smit - Laboratory Manager

RECEIVED
FEB 14 2000
MAXIM TECHNOLOGIES
HELENA, MT

Attachments: Chain of Custody
Sample Receipt Checklist

caj

As a mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of our clients and authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved pending our written approval. Test results apply specifically to the samples tested only. The entire report shall not be reproduced, except in full, without the written approval of the laboratory. Samples will be disposed of after testing is completed unless other arrangements are agreed to in writing.

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221022
Sample Name: COLUMN #1; PV-3
Sample Date: 12/27/99
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	443	mg/l	2320B	01/11/00
Alkalinity Carbonate as CO3	26	mg/l	2320B	01/11/00
Alkalinity Total as CaCO3	406	mg/l	2320B	01/11/00
Chloride as Cl	61	mg/l	325.3	01/06/00
Sulfate as SO4	46	mg/l	375.3	01/06/00
CATIONS				
Calcium as Ca	13	mg/l	6010B	01/07/00
Magnesium as Mg	3	mg/l	6010B	01/07/00
Sodium as Na	245	mg/l	6010B	01/07/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/19/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	01/07/00
Chemical Oxygen Demand	90	mg/l	410.1	01/21/00
pH	8.9	S.U.	150.1	01/05/00
Total Dissolved Solids	629	mg/l	160.2	01/05/00
Organic Carbon	34	mg/l	CALC.	01/21/99
NUTRIENTS				
Nitrate + Nitrite as N	<0.10	mg/l	353.2	01/07/00
Phosphorous Total	0.40	mg/l	365.2	01/14/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221023
Sample Name: COLUMN #2; PV-3
Sample Date: 12/27/99
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	284	mg/l	2320B	01/11/00
Alkalinity Carbonate as CO3	26	mg/l	2320B	01/11/00
Alkalinity Total as CaCO3	233	mg/l	2320B	01/11/00
Chloride as Cl	134,000	mg/l	325.3	01/06/00
Sulfate as SO4	169	mg/l	375.3	01/06/00
CATIONS				
Calcium as Ca	1550	mg/l	6010B	01/07/00
Magnesium as Mg	350	mg/l	6010B	01/07/00
Sodium as Na	69,100	mg/l	6010B	01/07/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/19/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	01/07/00
Chemical Oxygen Demand	3710	mg/l	410.1	01/21/00
pH	7.5	S.U.	150.1	01/05/00
Total Dissolved Solids	159,000	mg/l	160.2	01/05/00
Organic Carbon	1390	mg/l	CALC.	01/21/99
NUTRIENTS				
Nitrate + Nitrite as N	0.10	mg/l	353.2	01/07/00
Phosphorous Total	0.62	mg/l	365.2	01/14/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221024
Sample Name: COLUMN #3; PV-3
Sample Date: 12/27/99
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	416	mg/l	2320B	01/11/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/11/00
Alkalinity Total as CaCO3	341	mg/l	2320B	01/11/00
Chloride as Cl	134,000	mg/l	325.3	01/18/00
Sulfate as SO4	284	mg/l	375.3	01/06/00
CATIONS				
Calcium as Ca	2870	mg/l	6010B	01/07/00
Magnesium as Mg	760	mg/l	6010B	01/07/00
Sodium as Na	93,700	mg/l	6010B	01/09/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/19/00
INORGANICS				
Biochemical Oxygen Demand	1000	mg/l	405.1	01/07/00
Chemical Oxygen Demand	5430	mg/l	410.1	01/21/00
pH	7.0	S.U.	150.1	01/05/00
Total Dissolved Solids	232,000	mg/l	160.2	01/05/00
Organic Carbon	2040	mg/l	CALC.	01/21/99
NUTRIENTS				
Nitrate + Nitrite as N	32	mg/l	353.2	01/07/00
Phosphorous Total	0.81	mg/l	365.2	01/14/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221025
Sample Name: COLUMN #4; PV-3
Sample Date: 12/30/99
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	4090	mg/l	2320B	01/11/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/11/00
Alkalinity Total as CaCO3	3350	mg/l	2320B	01/11/00
Chloride as Cl	25,200	mg/l	325.3	01/06/00
Sulfate as SO4	922	mg/l	375.3	01/06/00
CATIONS				
Calcium as Ca	10,800	mg/l	6010B	01/07/00
Magnesium as Mg	760	mg/l	6010B	01/07/00
Sodium as Na	4190	mg/l	6010B	01/07/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/20/00
INORGANICS				
Biochemical Oxygen Demand	560	mg/l	405.1	01/07/00
Chemical Oxygen Demand	6880	mg/l	410.1	01/21/00
pH	6.9	S.U.	150.1	01/05/00
Total Dissolved Solids	55,100	mg/l	160.2	01/05/00
Organic Carbon	2580	mg/l	CALC.	01/21/99
NUTRIENTS				
Nitrate + Nitrite as N	0.59	mg/l	353.2	01/07/00
Phosphorous Total	3.06	mg/l	365.2	01/14/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221026
Sample Name: COLUMN #5; PV-3
Sample Date: 12/30/99
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	186	mg/l	2320B	01/11/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/11/00
Alkalinity Total as CaCO3	152	mg/l	2320B	01/11/00
Chloride as Cl	27,100	mg/l	325.3	01/18/00
Sulfate as SO4	92	mg/l	375.3	01/06/00
CATIONS				
Calcium as Ca	14,200	mg/l	6010B	01/07/00
Magnesium as Mg	390	mg/l	6010B	01/07/00
Sodium as Na	1660	mg/l	6010B	01/07/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/24/00
INORGANICS				
Biochemical Oxygen Demand	<105	mg/l	405.1	01/07/00
Chemical Oxygen Demand	796	mg/l	410.1	01/21/00
pH	7.3	S.U.	150.1	01/05/00
Total Dissolved Solids	40,600	mg/l	160.2	01/05/00
Organic Carbon	299	mg/l	CALC.	01/21/99
NUTRIENTS				
Nitrate + Nitrite as N	0.12	mg/l	353.2	01/07/00
Phosphorous Total	2.21	mg/l	365.2	01/14/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221027
Sample Name: COLUMN #6; PV-3
Sample Date: 12/27/99
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	6000	mg/l	2320B	01/11/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/11/00
Alkalinity Total as CaCO3	4920	mg/l	2320B	01/11/00
Chloride as Cl	20,800	mg/l	325.3	01/06/00
Sulfate as SO4	977	mg/l	375.3	01/06/00
CATIONS				
Calcium as Ca	2330	mg/l	6010B	01/07/00
Magnesium as Mg	6070	mg/l	6010B	01/07/00
Sodium as Na	4040	mg/l	6010B	01/07/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/24/00
INORGANICS				
Biochemical Oxygen Demand	660	mg/l	405.1	01/07/00
Chemical Oxygen Demand	17,400	mg/l	410.1	01/21/00
pH	6.8	S.U.	150.1	01/05/00
Total Dissolved Solids	52,500	mg/l	160.2	01/05/00
Organic Carbon	6530	mg/l	CALC.	01/21/99
NUTRIENTS				
Nitrate + Nitrite as N	<1.0	mg/l	353.2	01/07/00
Phosphorous Total	3.55	mg/l	365.2	01/14/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221028
Sample Name: COLUMN #7; PV-3
Sample Date: 12/23/99
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	331	mg/l	2320B	01/11/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/11/00
Alkalinity Total as CaCO3	271	mg/l	2320B	01/11/00
Chloride as Cl	9850	mg/l	325.3	01/06/00
Sulfate as SO4	181	mg/l	375.3	01/06/00
CATIONS				
Calcium as Ca	530	mg/l	6010B	01/07/00
Magnesium as Mg	2830	mg/l	6010B	01/07/00
Sodium as Na	900	mg/l	6010B	01/07/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/25/00
INORGANICS				
Biochemical Oxygen Demand	<3.0	mg/l	405.1	01/07/00
Chemical Oxygen Demand	362	mg/l	410.1	01/21/00
pH	8.2	S.U.	150.1	01/05/00
Total Dissolved Solids	16,100	mg/l	160.2	01/05/00
Organic Carbon	136	mg/l	CALC.	01/21/99
NUTRIENTS				
Nitrate + Nitrite as N	0.15	mg/l	353.2	01/07/00
Phosphorous Total	0.37	mg/l	365.2	01/14/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221031
Sample Name: DUPLICATE OF 221022
Sample Date: NONE GIVEN
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	443	mg/l	2320B	01/11/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/11/00
Alkalinity Total as CaCO3	406	mg/l	2320B	01/11/00
Chloride as Cl	59	mg/l	325.3	01/06/00
Sulfate as SO4	46	mg/l	375.3	01/06/00
CATIONS				
Calcium as Ca	13	mg/l	6010B	01/07/00
Magnesium as Mg	4	mg/l	6010B	01/07/00
Sodium as Na	242	mg/l	6010B	01/07/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/20/00
INORGANICS				
Biochemical Oxygen Demand	NA			
Chemical Oxygen Demand	109	mg/l	410.1	01/21/00
pH	8.9	S.U.	150.1	01/05/00
Total Dissolved Solids	651	mg/l	160.2	01/05/00
Organic Carbon	41	mg/l	CALC.	01/21/99
NUTRIENTS				
Nitrate + Nitrite as N	<0.10	mg/l	353.2	01/07/00
Phosphorous Total	0.36	mg/l	365.2	01/14/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221032
Sample Name: SPIKE OF 221028
Sample Date: NONE GIVEN
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	NA			
Alkalinity Carbonate as CO3	NA			
Alkalinity Total as CaCO3	97	% [89-106]	2320B	01/11/00
Chloride as Cl	98	% [84-113]	325.3	01/06/00
Sulfate as SO4	104	% [89-110]	375.3	01/06/00
CATIONS				
Calcium as Ca	93	% [90-110]	6010B	01/07/00
Magnesium as Mg	89	% [88-112]	6010B	01/07/00
Sodium as Na	93	% [86-114]	6010B	01/07/00
CORROSIVITY				
Steel Coupon Index	NA			
INORGANICS				
Biochemical Oxygen Demand	NA			
Chemical Oxygen Demand	96	% [90-111]	410.1	01/21/00
pH	NA			
Total Dissolved Solids	NA			
NUTRIENTS				
Nitrate + Nitrite as N	96	% [89-113]	353.2	01/07/00
Phosphorous Total	NA			
SOIL				
Organic Carbon	NA			

Pore Volume-4

NORTHERN
Analytical Laboratories, Inc.

602 South 25th Street
P O Box 30315
Billings, MT 59107
Telephone: (406) 254-7226
Fax: (406) 254-1389

REPORT TO: ATTN: DAVE JACOBSON
MAXIM TECHNOLOGIES, INC.
P O BOX 4699
HELENA MT 59604

DATE: February 17, 2000
JOB NUMBER: 87-911
SHEET: 1 of 10
INVOICE NO.: 25517073

REPORT OF: Water Analysis - MDT Column Tests – 9911852.100

CASE NARRATIVE:

On January 11, 2000, these water samples (laboratory numbers 221186 through 221192) were received in our laboratory for analysis. Tests were conducted in accordance with EPA/600/4-79-020 *"Methods for Chemical Analysis of Water and Wastes"*; *"Standard Methods for the Examination of Water and Wastewater"*, 18th Edition; SW-846 *"Test Methods for Evaluating Solid Waste"*, 3rd Edition, updates I, II, IIA, IIB, III.

The condition of the samples upon receipt at the laboratory is noted on the attached sample receipt checklist Chain of custody documentation is enclosed.

The test results are shown on the following pages.

A <sign indicates the value reported was the practical quantitation limit for this sample using the method described. Concentrations of analyte, if present, below this were not quantifiable.

Footnote: (1) The recovery is outside the stated control limits. The associated lab control sample recovery was acceptable at 107%.

Reviewed by _____
Denise Jensen
Quality Assurance Coordinator

RECEIVED
FEB 2 8 2000
MAXIM TECHNOLOGIES
HELENA, MT

Attachments: Chain of Custody
Sample Receipt Checklist

caj

As a mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of our clients and authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved pending our written approval. Test results apply specifically to the samples tested only. The entire report shall not be reproduoed, except in full, without the written approval of the laboratory. Samples will be disposed of after testing is completed unless other arrangements are agreed to in writing.

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221186
Sample Name: COLUMN 1, PV-4
Sample Date: 12/28/99
Collected by: TOM TANGEN AND SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	390	mg/l	2320B	01/11/00
Alkalinity Carbonate as CO3	32	mg/l	2320B	01/11/00
Alkalinity Total as CaCO3	374	mg/l	2320B	01/11/00
Chloride as Cl	10	mg/l	325.3	01/18/00
Sulfate as SO4	26	mg/l	375.3	01/12/00
CATIONS				
Calcium as Ca	6	mg/l	6010B	01/12/00
Magnesium as Mg	2	mg/l	6010B	01/12/00
Sodium as Na	164	mg/l	6010B	01/12/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	01/31/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	01/12/00
Chemical Oxygen Demand	72	mg/l	410.1	01/21/00
pH	9.0	S.U.	150.1	01/11/00
Total Dissolved Solids	525	mg/l	160.1	01/11/00
Organic Carbon	27	mg/l	CALC.	01/21/00
NUTRIENTS				
Nitrate + Nitrite as N	<0.1	mg/l	353.2	01/21/00
Phosphorous Total	0.45	mg/l	365.2	01/14/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221187
Sample Name: COLUMN 2, PV-4
Sample Date: 12/28/99
Collected by: TOM TANGEN AND SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	602	mg/l	2320B	01/11/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/11/00
Alkalinity Total as CaCO3	493	mg/l	2320B	01/11/00
Chloride (Water Soluble)	71,100	mg/l	325.3	02/15/00
Sulfate as SO4	142	mg/l	375.3	01/12/00
CATIONS				
Calcium as Ca	508	mg/l	6010B	01/12/00
Magnesium as Mg	140	mg/l	6010B	01/12/00
Sodium as Na	44,700	mg/l	6010B	01/12/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/01/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	01/12/00
Chemical Oxygen Demand	1360	mg/l	410.1	01/21/00
pH	8.1	S.U.	150.1	01/11/00
Total Dissolved Solids	103,000	mg/l	160.1	01/11/00
Organic Carbon	510	mg/l	CALC.	01/21/00
NUTRIENTS				
Nitrate + Nitrite as N	0.16	mg/l	353.2	01/21/00
Phosphorous Total	0.93	mg/l	365.2	01/14/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221188
Sample Name: COLUMN 3, PV-4
Sample Date: 12/28/99
Collected by: TOM TANGEN AND SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	899	mg/l	2320B	01/11/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/11/00
Alkalinity Total as CaCO3	737	mg/l	2320B	01/11/00
Chloride (Water Soluble)	85,500	mg/l	325.3	01/18/00
Sulfate as SO4	222	mg/l	375.3	01/12/00
CATIONS				
Calcium as Ca	625 -	mg/l	6010B	01/12/00
Magnesium as Mg	274	mg/l	6010B	01/12/00
Sodium as Na	64,600	mg/l	6010B	01/12/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/01/00
INORGANICS				
Biochemical Oxygen Demand	241 -	mg/l	405.1	01/12/00
Chemical Oxygen Demand	2530	mg/l	410.1	01/21/00
pH	7.6	S.U.	150.1	01/11/00
Total Dissolved Solids	143,000	mg/l	160.1	01/11/00
Organic Carbon	949	mg/l	CALC.	01/21/00
NUTRIENTS				
Nitrate + Nitrite as N	<2.5	mg/l	353.2	01/21/00
Phosphorous Total	2.43	mg/l	365.2	01/14/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221189
Sample Name: COLUMN 4, PV-4
Sample Date: 12/31/99
Collected by: TOM TANGEN AND SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	926	mg/l	2320B	01/11/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/11/00
Alkalinity Total as CaCO3	759	mg/l	2320B	01/11/00
Chloride (Water Soluble)	4280	mg/l	325.3	01/18/00
Sulfate as SO4	311	mg/l	375.3	01/12/00
CATIONS				
Calcium as Ca	1240	mg/l	6010B	02/15/00
Magnesium as Mg	139	mg/l	6010B	02/15/00
Sodium as Na	1030	mg/l	6010B	02/15/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/02/00
INORGANICS				
Biochemical Oxygen Demand	<200	mg/l	405.1	01/12/00
Chemical Oxygen Demand	2350	mg/l	410.1	01/21/00
pH	7.5	S.U.	150.1	01/11/00
Total Dissolved Solids	9320	mg/l	160.1	01/11/00
Organic Carbon	881	mg/l	CALC.	01/21/00
NUTRIENTS				
Nitrate + Nitrite as N	<0.5	mg/l	353.2	01/21/00
Phosphorous Total	1.86	mg/l	365.2	01/14/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221190
Sample Name: COLUMN 5, PV-4
Sample Date: 12/31/99
Collected by: TOM TANGEN AND SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	255	mg/l	2320B	01/11/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/11/00
Alkalinity Total as CaCO3	209	mg/l	2320B	01/11/00
Chloride (Water Soluble)	4310	mg/l	325.3	01/18/00
Sulfate as SO4	65	mg/l	375.3	01/12/00
CATIONS				
Calcium as Ca	1940	mg/l	6010B	01/12/00
Magnesium as Mg	59	mg/l	6010B	01/12/00
Sodium as Na	450	mg/l	6010B	01/12/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/03/00
INORGANICS				
Biochemical Oxygen Demand	<16	mg/l	405.1	01/12/00
Chemical Oxygen Demand	253	mg/l	410.1	01/21/00
pH	7.8	S.U.	150.1	01/11/00
Total Dissolved Solids	7840	mg/l	160.1	01/11/00
Organic Carbon	95	mg/l	CALC.	01/21/00
NUTRIENTS				
Nitrate + Nitrite as N	<0.1	mg/l	353.2	01/21/00
Phosphorous Total	1.36	mg/l	365.2	01/14/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221191
Sample Name: COLUMN 6, PV-4
Sample Date: 12/28/99
Collected by: TOM TANGEN AND SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	5440	mg/l	2320B	01/11/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/11/00
Alkalinity Total as CaCO3	4460	mg/l	2320B	01/11/00
Chloride (Water Soluble)	16,600	mg/l	325.3	01/18/00
Sulfate as SO4	803	mg/l	375.3	01/12/00
CATIONS				
Calcium as Ca	1630	mg/l	6010B	01/12/00
Magnesium as Mg	4430	mg/l	6010B	01/12/00
Sodium as Na	3540	mg/l	6010B	01/12/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/03/00
INORGANICS				
Biochemical Oxygen Demand	>3600	mg/l	405.1	01/12/00
Chemical Oxygen Demand	17,000	mg/l	410.1	01/21/00
pH	6.9	S.U.	150.1	01/11/00
Total Dissolved Solids	40,200	mg/l	160.1	01/11/00
Organic Carbon	6380	mg/l	CALC.	01/21/00
NUTRIENTS				
Nitrate + Nitrite as N	1.66	mg/l	353.2	01/21/00
Phosphorous Total	3.91	mg/l	365.2	01/14/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221192
Sample Name: COLUMN 7, PV-4
Sample Date: 12/24/99
Collected by: TOM TANGEN AND SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	278	mg/l	2320B	01/11/00
Alkalinity Carbonate as CO3	52	mg/l	2320B	01/11/00
Alkalinity Total as CaCO3	325	mg/l	2320B	01/11/00
Chloride (Water Soluble)	1070	mg/l	325.3	01/18/00
Sulfate as SO4	121	mg/l	375.3	01/12/00
CATIONS				
Calcium as Ca	56	mg/l	6010B	01/12/00
Magnesium as Mg	299	mg/l	6010B	01/12/00
Sodium as Na	284	mg/l	6010B	01/12/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/03/00
INORGANICS				
Biochemical Oxygen Demand	<4	mg/l	405.1	01/12/00
Chemical Oxygen Demand	109	mg/l	410.1	01/21/00
pH	8.7	S.U.	150.1	01/11/00
Total Dissolved Solids	2360	mg/l	160.1	01/11/00
Organic Carbon	41	mg/l	CALC.	01/21/00
NUTRIENTS				
Nitrate + Nitrite as N	<0.1	mg/l	353.2	01/21/00
Phosphorous Total	0.37	mg/l	365.2	01/14/00

mmpy – millimeters of corrosion of a steel coupon per year

Pore Volume-5

NORTHERN
Analytical Laboratories, Inc.

602 South 25th Street
P O Box 30315
Billings, MT 59107
Telephone: (406) 254-7226
Fax: (406) 254-1389

REPORT TO: ATTN: DAVE JACOBSON
MAXIM TECHNOLOGIES, INC.
P O BOX 4699
HELENA MT 59604

DATE: February 17, 2000
JOB NUMBER: 87-911
SHEET: 1 of 12
INVOICE NO.: 25517129

REPORT OF: Water Analysis - MDT Column Tests – 9911852.100

CASE NARRATIVE:

On January 19, 2000, these water samples (laboratory numbers 221361 through 221367) were received in our laboratory for analysis. Tests were conducted in accordance with EPA/600/4-79-020 *"Methods for Chemical Analysis of Water and Wastes"*; *"Standard Methods for the Examination of Water and Wastewater"*, 18th Edition; SW-846 *"Test Methods for Evaluating Solid Waste"*, 3rd Edition, updates I, II, IIA, IIB, III.

The condition of the samples upon receipt at the laboratory is noted on the attached sample receipt checklist Chain of custody documentation is enclosed.

The test results are shown on the following pages.

A <sign indicates the value reported was the practical quantitation limit for this sample using the method described. Concentrations of analyte, if present, below this were not quantifiable.

Footnote: (1) The recovery is outside the stated control limits. The associated lab control sample recovery was acceptable at 105%.

Reviewed by _____
Denise Jensen
Quality Assurance Coordinator

RECEIVED
FEB 28 2000
MAXIM TECHNOLOGIES
HELENA, MT

Attachments: Chain of Custody
Sample Receipt Checklist

caj

As a mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of our clients and authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved pending our written approval. Test results apply specifically to the samples tested only. The entire report shall not be reproduced, except in full, without the written approval of the laboratory. Samples will be disposed of after testing is completed unless other arrangements are agreed to in writing.

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221361
Sample Name: COL 1, PV-5
Sample Date: 01/11/00
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	403	mg/l	2320B	01/25/00
Alkalinity Carbonate as CO3	16	mg/l	2320B	01/25/00
Alkalinity Total as CaCO3	358	mg/l	2320B	01/25/00
Chloride as Cl	2	mg/l	325.3	01/26/00
Sulfate as SO4	21	mg/l	375.3	01/24/00
CATIONS				
Calcium as Ca	7	mg/l	6010B	01/19/00
Magnesium as Mg	2	mg/l	6010B	01/19/00
Sodium as Na	162	mg/l	6010B	01/19/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/07/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	01/19/00
Chemical Oxygen Demand	25	mg/l	410.1	01/21/00
pH	8.9	S.U.	150.1	01/19/00
Total Dissolved Solids	520	mg/l	160.1	01/19/00
Organic Carbon	9	mg/l	CALC.	01/21/00
NUTRIENTS				
Nitrate + Nitrite as N	<0.1	mg/l	353.2	01/21/00
Phosphorous Total	0.32	mg/l	365.2	01/31/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221362
Sample Name: COL 2, PV-5
Sample Date: 01/11/00
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	1060	mg/l	2320B	01/25/00
Alkalinity Carbonate as CO3	130	mg/l	2320B	01/25/00
Alkalinity Total as CaCO3	1080	mg/l	2320B	01/25/00
Chloride as Cl	48,200	mg/l	325.3	02/15/00
Sulfate as SO4	194	mg/l	375.3	01/24/00
CATIONS				
Calcium as Ca	124	mg/l	6010B	01/19/00
Magnesium as Mg	28	mg/l	6010B	01/19/00
Sodium as Na	33,000	mg/l	6010B	01/19/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/07/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	01/19/00
Chemical Oxygen Demand	2750	mg/l	410.1	01/21/00
pH	8.8	S.U.	150.1	01/19/00
Total Dissolved Solids	72,700	mg/l	160.1	01/19/00
Organic Carbon	1030	mg/l	CALC.	01/21/00
NUTRIENTS				
Nitrate + Nitrite as N	<0.1	mg/l	353.2	01/21/00
Phosphorous Total	6.3	mg/l	365.2	01/31/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221363
Sample Name: COL 3, PV-5
Sample Date: 01/11/00
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	2470	mg/l	2320B	01/25/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/25/00
Alkalinity Total as CaCO3	2020	mg/l	2320B	01/25/00
Chloride as Cl	44,100	mg/l	325.3	02/15/00
Sulfate as SO4	246	mg/l	375.3	01/24/00
CATIONS				
Calcium as Ca	49	mg/l	6010B	01/19/00
Magnesium as Mg	47	mg/l	6010B	01/19/00
Sodium as Na	31,700	mg/l	6010B	01/19/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/08/00
INORGANICS				
Biochemical Oxygen Demand	<100	mg/l	405.1	01/19/00
Chemical Oxygen Demand	1270	mg/l	410.1	01/21/00
pH	8.5	S.U.	150.1	01/19/00
Total Dissolved Solids	71,000	mg/l	160.1	01/19/00
Organic Carbon	476	mg/l	CALC.	01/21/00
NUTRIENTS				
Nitrate + Nitrite as N	<2.5	mg/l	353.2	01/21/00
Phosphorous Total	1.43	mg/l	365.2	01/31/00

mmpy – millimeters of corrosion of a steel coupon per year

nt Name: MAXIM - HELENA, MT
oject No.: 87-911
boratory No.: 221364
le Name: COL 4, PV-5
mple Date: 01/14/00
llected by: SCOTT COLVIN
Sampled: NONE GIVEN
e Type: WATER

AMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ONS				
nity, Bicarbonate as HCO3	876	mg/l	2320B	01/25/00
nity Carbonate as CO3	0	mg/l	2320B	01/25/00
linity Total as CaCO3	718	mg/l	2320B	01/25/00
de as Cl	1940	mg/l	325.3	01/26/00
as SO4	265	mg/l	375.3	01/24/00
ONS				
as Ca	536	mg/l	6010B	02/15/00
sium as Mg	71	mg/l	6010B	02/15/00
as Na	608	mg/l	6010B	02/15/00
IVITY				
upon Index	<1	mmpy	1110	02/08/00
NICS				
al Oxygen Demand	20	mg/l	405.1	01/19/00
l Oxygen Demand	905	mg/l	410.1	01/21/00
	7.9	S.U.	150.1	01/19/00
solved Solids	5680	mg/l	160.1	01/19/00
Carbon	339	mg/l	CALC.	01/21/00
+ Nitrite as N	1.68	mg/l	353.2	01/21/00
s Total	0.91	mg/l	365.2	01/31/00

nillimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221365
Sample Name: COL 5, PV-5
Sample Date: 01/14/00
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	370	mg/l	2320B	01/25/00
Alkalinity Carbonate as CO3	13	mg/l	2320B	01/25/00
Alkalinity Total as CaCO3	325	mg/l	2320B	01/25/00
Chloride as Cl	126	mg/l	325.3	01/26/00
Sulfate as SO4	50	mg/l	375.3	01/24/00
CATIONS				
Calcium as Ca	101	mg/l	6010B	01/19/00
Magnesium as Mg	4	mg/l	6010B	01/19/00
Sodium as Na	105	mg/l	6010B	01/19/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/08/00
INORGANICS				
Biochemical Oxygen Demand	<4	mg/l	405.1	01/19/00
Chemical Oxygen Demand	97	mg/l	410.1	01/21/00
pH	8.7	S.U.	150.1	01/19/00
Total Dissolved Solids	697	mg/l	160.1	01/19/00
Organic Carbon	36	mg/l	CALC.	01/21/00
NUTRIENTS				
Nitrate + Nitrite as N	0.17	mg/l	353.2	01/21/00
Phosphorous Total	1.29	mg/l	365.2	01/31/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221366
Sample Name: COL 6, PV-5
Sample Date: 01/13/00
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	2450	mg/l	2320B	01/25/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/25/00
Alkalinity Total as CaCO3	2010	mg/l	2320B	01/25/00
Chloride as Cl	1950	mg/l	325.3	01/26/00
Sulfate as SO4	268	mg/l	375.3	01/24/00
CATIONS				
Calcium as Ca	106	mg/l	6010B	01/19/00
Magnesium as Mg	654	mg/l	6010B	01/19/00
Sodium as Na	710	mg/l	6010B	01/19/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/09/00
INORGANICS				
Biochemical Oxygen Demand	902	mg/l	405.1	01/19/00
Chemical Oxygen Demand	1830	mg/l	410.1	01/21/00
pH	8.4	S.U.	150.1	01/19/00
Total Dissolved Solids	6430	mg/l	160.1	01/19/00
Organic Carbon	686	mg/l	CALC.	01/21/00
NUTRIENTS				
Nitrate + Nitrite as N	<1	mg/l	353.2	01/21/00
Phosphorous Total	3.55	mg/l	365.2	01/31/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221367
Sample Name: COL 7, PV-5
Sample Date: 01/13/00
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	344	mg/l	2320B	01/25/00
Alkalinity Carbonate as CO3	13	mg/l	2320B	01/25/00
Alkalinity Total as CaCO3	304	mg/l	2320B	01/25/00
Chloride as Cl	59	mg/l	325.3	01/26/00
Sulfate as SO4	33	mg/l	375.3	01/24/00
CATIONS				
Calcium as Ca	22	mg/l	6010B	01/19/00
Magnesium as Mg	36	mg/l	6010B	01/19/00
Sodium as Na	92	mg/l	6010B	01/19/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/09/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	01/19/00
Chemical Oxygen Demand	47	mg/l	410.1	01/21/00
pH	8.8	S.U.	150.1	01/19/00
Total Dissolved Solids	521	mg/l	160.1	01/19/00
Organic Carbon	18	mg/l	CALC.	01/21/00
NUTRIENTS				
Nitrate + Nitrite as N	<0.1	mg/l	353.2	01/21/00
Phosphorous Total	0.25	mg/l	365.2	01/31/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221368
Sample Name: SPIKE OF 221361
Sample Date: 01/13/00
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	NA			
Alkalinity Carbonate as CO3	NA			
Alkalinity Total as CaCO3	98	% [89-106]	2320B	01/25/00
Chloride as Cl	104	% [84-113]	325.3	01/26/00
Sulfate as SO4	79(1)	% [88-110]	375.3	01/24/00
CATIONS				
Calcium as Ca	100	% [90-110]	6010B	01/19/00
Magnesium as Mg	95	% [88-112]	6010B	01/19/00
Sodium as Na	100	% [86-114]	6010B	01/19/00
CORROSIVITY				
Steel Coupon Index	NA			
INORGANICS				
Biochemical Oxygen Demand	NA			
Chemical Oxygen Demand	105	% [90-11]	410.1	01/21/00
pH	NA			
Total Dissolved Solids	NA			
Organic Carbon	NA			
NUTRIENTS				
Nitrate + Nitrite as N	109	% [89-113]	353.2	01/21/00
Phosphorous Total	109	% [81-119]	365.2	01/31/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221369
Sample Name: DUPLICATE OF 221367
Sample Date: 01/13/00
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	331	mg/l	2320B	01/25/00
Alkalinity Carbonate as CO3	13	mg/l	2320B	01/25/00
Alkalinity Total as CaCO3	293	mg/l	2320B	01/25/00
Chloride as Cl	67	mg/l	325.3	01/26/00
Sulfate as SO4	29	mg/l	375.3	01/24/00
CATIONS				
Calcium as Ca	24	mg/l	6010B	01/19/00
Magnesium as Mg	37	mg/l	6010B	01/19/00
Sodium as Na	91	mg/l	6010B	01/19/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/09/00
INORGANICS				
Biochemical Oxygen Demand	NA			
Chemical Oxygen Demand	43	mg/l	410.1	01/21/00
pH	8.8	S.U.	150.1	01/19/00
Total Dissolved Solids	482	mg/l	160.1	01/19/00
Organic Carbon	16	mg/l	CALC.	01/21/00
NUTRIENTS				
Nitrate + Nitrite as N	<0.1	mg/l	353.2	01/21/00
Phosphorous Total	0.22	mg/l	365.2	01/31/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221370
Sample Name: METHOD BLANK
Sample Date: NONE GIVEN
Collected by: PREPARED BY LABORATORY
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	<1	mg/l	2320B	01/25/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/25/00
Alkalinity Total as CaCO3	<1	mg/l	2320B	01/25/00
Chloride as Cl	<1	mg/l	325.3	01/26/00
Sulfate as SO4	<5	mg/l	375.3	01/24/00
CATIONS				
Calcium as Ca	<1	mg/l	6010B	01/19/00
Magnesium as Mg	<1	mg/l	6010B	01/19/00
Sodium as Na	<1	mg/l	6010B	01/19/00
CORROSIVITY				
Steel Coupon Index	NA			
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	01/19/00
Chemical Oxygen Demand	<5	mg/l	410.1	01/21/00
pH	NA			
Total Dissolved Solids	<10	mg/l	160.1	01/19/00
Organic Carbon	NA			
NUTRIENTS				
Nitrate + Nitrite as N	<0.05	mg/l	353.2	01/21/00
Phosphorous Total	<0.01	mg/l	365.2	01/31/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221371
Sample Name: LABORATORY CONTROL SAMPLE
Sample Date: NONE GIVEN
Collected by: PREPARED BY LABORATORY
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	NA			
Alkalinity Carbonate as CO3	NA			
Alkalinity Total as CaCO3	110	% [80-120]	2320B	01/25/00
Chloride as Cl	96	% [80-120]	325.3	01/26/00
Sulfate as SO4	106	% [80-120]	375.3	01/24/00
CATIONS				
Calcium as Ca	109	% [80-120]	6010B	01/19/00
Magnesium as Mg	101	% [80-120]	6010B	01/19/00
Sodium as Na	102	% [80-120]	6010B	01/19/00
CORROSIVITY				
Steel Coupon Index	NA			
INORGANICS				
Biochemical Oxygen Demand	84	% [80-120]	405.1	01/19/00
Chemical Oxygen Demand	93	% [80-120]	410.1	01/21/00
pH	NA			
Total Dissolved Solids	101	% [80-120]	160.1	01/19/00
Organic Carbon	NA			
NUTRIENTS				
Nitrate + Nitrite as N	109	% [80-120]	353.2	01/21/00
Phosphorous Total	104	% [80-120]	365.2	01/31/00

mmpy – millimeters of corrosion of a steel coupon per year

Pore Volume-6

NORTHERN
Analytical Laboratories, Inc.

602 South 25th Street
P O Box 30315
Billings, MT 59107
Telephone: (406) 254-7226
Fax: (406) 254-1389

REPORT TO: ATTN: TOM TANGEN
MAXIM TECHNOLOGIES, INC.
P O BOX 4699
HELENA MT 59604

DATE: February 25, 2000
JOB NUMBER: 87-911
SHEET: 1 of 12
INVOICE NO.: 25517165

REPORT OF: Water Analysis - MDT Column Tests – 9911852.100

CASE NARRATIVE:

On January 25, 2000, these water samples (laboratory numbers 221498 through 221504) were received in our laboratory for analysis. Tests were conducted in accordance with EPA/600/4-79-020 *"Methods for Chemical Analysis of Water and Wastes"; "Standard Methods for the Examination of Water and Wastewater"*, 18th Edition; SW-846 *"Test Methods for Evaluating Solid Waste"*, 3rd Edition, updates I, II, IIA, IIB, III.

The condition of the samples upon receipt at the laboratory is noted on the attached sample receipt checklist Chain of custody documentation is enclosed.

The test results are shown on the following pages.

A <sign indicates the value reported was the practical quantitation limit for this sample using the method described. Concentrations of analyte, if present, below this were not quantifiable.

Footnote: (1) The recovery is outside the stated control limits. A pin size hole in the filter used for gravimetric analysis of the matrix spike sample was the cause of the low recovery of sulfate. There was not sufficient sample to repeat the matrix spike analysis. The concentrations reported for the samples associated with this spiked sample should NOT be qualified as estimates as the filter problem was associated only with the spiked sample.

Reviewed by _____
Kathleen A. Smit – Laboratory Manager

RECEIVED
FEB 28 2000
MAXIM TECHNOLOGIES
HELENA, MT

Attachments: Chain of Custody
Sample Receipt Checklist

caj

As a mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of our clients and authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved pending our written approval. Test results apply specifically to the samples tested only. The entire report shall not be reproduced, except in full, without the written approval of the laboratory. Samples will be disposed of after testing is completed unless other arrangements are agreed to in writing.

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221498
Sample Name: COL. #1, PV-6
Sample Date: 01/19/00
Collected by: TOM TANGEN & SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	364	mg/l	2320B	01/25/00
Alkalinity Carbonate as CO3	20	mg/l	2320B	01/25/00
Alkalinity Total as CaCO3	331	mg/l	2320B	01/25/00
Chloride as Cl	1	mg/l	325.3	01/26/00
Sulfate as SO4	34	mg/l	375.3	02/10/00
CATIONS				
Calcium as Ca	7	mg/l	6010B	02/02/00
Magnesium as Mg	3	mg/l	6010B	02/02/00
Sodium as Na	168	mg/l	6010B	02/02/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/15/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	01/26/00
Chemical Oxygen Demand	36	mg/l	410.2	02/01/00
pH	8.7	S.U.	150.1	01/25/00
Total Dissolved Solids	462	mg/l	160.1	01/26/00
Organic Carbon	14	mg/l	CALC.	02/01/00
NUTRIENTS				
Nitrate + Nitrite as N	<0.10	mg/l	353.2	02/16/00
Phosphorous Total	0.62	mg/l	365.2	01/31/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221499
Sample Name: COL. #2, PV-6
Sample Date: 01/19/00
Collected by: TOM TANGEN & SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	760	mg/l	2320B	01/25/00
Alkalinity Carbonate as CO3	211	mg/l	2320B	01/25/00
Alkalinity Total as CaCO3	976	mg/l	2320B	01/25/00
Chloride as Cl	1310	mg/l	325.3	02/15/00
Sulfate as SO4	100	mg/l	375.3	02/10/00
CATIONS				
Calcium as Ca	17	mg/l	6010B	02/02/00
Magnesium as Mg	8	mg/l	6010B	02/02/00
Sodium as Na	1450	mg/l	6010B	02/15/00
CORROSIVITY				
Steel Coupon Index	1	mmpy	1110	02/15/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	01/26/00
Chemical Oxygen Demand	194	mg/l	410.1	02/04/00
pH	9.6	S.U.	150.1	01/25/00
Total Dissolved Solids	4290	mg/l	160.1	01/26/00
Organic Carbon	73	mg/l	CALC.	02/01/00
NUTRIENTS				
Nitrate + Nitrite as N	<0.05	mg/l	353.2	02/16/00
Phosphorous Total	4.0	mg/l	365.2	01/31/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221500
Sample Name: COL. #3, PV-6
Sample Date: 01/19/00
Collected by: TOM TANGEN & SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	2530	mg/l	2320B	01/25/00
Alkalinity Carbonate as CO3	211	mg/l	2320B	01/25/00
Alkalinity Total as CaCO3	2430	mg/l	2320B	01/25/00
Chloride as Cl	6550	mg/l	325.3	02/15/00
Sulfate as SO4	105	mg/l	375.3	02/10/00
CATIONS				
Calcium as Ca	9	mg/l	6010B	02/02/00
Magnesium as Mg	3	mg/l	6010B	02/02/00
Sodium as Na	6230	mg/l	6010B	02/15/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/15/00
INORGANICS				
Biochemical Oxygen Demand	<20	mg/l	405.1	01/26/00
Chemical Oxygen Demand	364	mg/l	410.1	02/04/00
pH	9.0	S.U.	150.1	01/25/00
Total Dissolved Solids	13,400	mg/l	160.1	01/26/00
Organic Carbon	136	mg/l	CALC.	02/04/00
NUTRIENTS				
Nitrate + Nitrite as N	0.92	mg/l	353.2	02/16/00
Phosphorous Total	4.01	mg/l	365.2	01/31/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221501
Sample Name: COL. #4, PV-6
Sample Date: 01/21/00
Collected by: TOM TANGEN & SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	843	mg/l	2320B	01/25/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/25/00
Alkalinity Total as CaCO3	691	mg/l	2320B	01/25/00
Chloride as Cl	846	mg/l	325.3	01/26/00
Sulfate as SO4	196	mg/l	375.3	02/10/00
CATIONS				
Calcium as Ca	250	mg/l	6010B	02/15/00
Magnesium as Mg	40	mg/l	6010B	02/15/00
Sodium as Na	458	mg/l	6010B	02/15/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/16/00
INORGANICS				
Biochemical Oxygen Demand	13	mg/l	405.1	01/26/00
Chemical Oxygen Demand	970	mg/l	410.1	02/04/00
pH	8.0	S.U.	150.1	01/25/00
Total Dissolved Solids	3150	mg/l	160.1	01/26/00
Organic Carbon	364	mg/l	CALC.	02/04/00
NUTRIENTS				
Nitrate + Nitrite as N	35.2	mg/l	353.2	02/16/00
Phosphorous Total	1.02	mg/l	365.2	01/31/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221502
Sample Name: COL. #5, PV-6
Sample Date: 01/21/00
Collected by: TOM TANGEN & SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	317	mg/l	2320B	01/25/00
Alkalinity Carbonate as CO3	13	mg/l	2320B	01/25/00
Alkalinity Total as CaCO3	282	mg/l	2320B	01/25/00
Chloride as Cl	19	mg/l	325.3	01/26/00
Sulfate as SO4	27	mg/l	375.3	02/10/00
CATIONS				
Calcium as Ca	63	mg/l	6010B	02/02/00
Magnesium as Mg	2	mg/l	6010B	02/02/00
Sodium as Na	77	mg/l	6010B	02/02/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/16/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	01/26/00
Chemical Oxygen Demand	73	mg/l	410.1	02/04/00
pH	8.6	S.U.	150.1	01/25/00
Total Dissolved Solids	417	mg/l	160.1	01/26/00
Organic Carbon	27	mg/l	CALC.	02/04/00
NUTRIENTS				
Nitrate + Nitrite as N	0.35	mg/l	353.2	02/16/00
Phosphorous Total	1.96	mg/l	365.2	01/31/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221503
Sample Name: COL. #6, PV-6
Sample Date: 01/21/00
Collected by: TOM TANGEN & SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	1400	mg/l	2320B	01/25/00
Alkalinity Carbonate as CO3	179	mg/l	2320B	01/25/00
Alkalinity Total as CaCO3	1450	mg/l	2320B	01/25/00
Chloride as Cl	204	mg/l	325.3	01/26/00
Sulfate as SO4	170	mg/l	375.3	02/10/00
CATIONS				
Calcium as Ca	43	mg/l	6010B	02/15/00
Magnesium as Mg	172	mg/l	6010B	02/15/00
Sodium as Na	216	mg/l	6010B	02/15/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/16/00
INORGANICS				
Biochemical Oxygen Demand	<200	mg/l	405.1	01/26/00
Chemical Oxygen Demand	471	mg/l	410.1	02/04/00
pH	8.8	S.U.	150.1	01/25/00
Total Dissolved Solids	2090	mg/l	160.1	01/26/00
Organic Carbon	177	mg/l	CALC.	02/04/00
NUTRIENTS				
Nitrate + Nitrite as N	12.5	mg/l	353.2	02/16/00
Phosphorous Total	2.34	mg/l	365.2	01/31/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221504
Sample Name: COL. #7, PV-6
Sample Date: 01/21/00
Collected by: TOM TANGEN & SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	304	mg/l	2320B	01/25/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/25/00
Alkalinity Total as CaCO3	276	mg/l	2320B	01/25/00
Chloride as Cl	15	mg/l	325.3	01/26/00
Sulfate as SO4	18	mg/l	375.3	02/10/00
CATIONS				
Calcium as Ca	8	mg/l	6010B	02/02/00
Magnesium as Mg	30	mg/l	6010B	02/02/00
Sodium as Na	84	mg/l	6010B	02/02/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/17/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	01/26/00
Chemical Oxygen Demand	34	mg/l	410.2	02/01/00
pH	8.7	S.U.	150.1	01/25/00
Total Dissolved Solids	331	mg/l	160.1	01/26/00
Organic Carbon	13	mg/l	CALC.	02/04/00
NUTRIENTS				
Nitrate + Nitrite as N	0.08	mg/l	353.2	02/16/00
Phosphorous Total	0.32	mg/l	365.2	01/31/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221505
Sample Name: SPIKE OF 221498
Sample Date: 01/19/00
Collected by: TOM TANGEN & SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	NA			
Alkalinity Carbonate as CO3	NA			
Alkalinity Total as CaCO3	98	% [89-106]	2320B	01/25/00
Chloride as Cl	102	% [84-113]	325.3	01/26/00
Sulfate as SO4	40(1)	% [88-110]	375.3	02/10/00
CATIONS				
Calcium as Ca	106	% [90-110]	6010B	02/02/00
Magnesium as Mg	100	% [88-112]	6010B	02/02/00
Sodium as Na	99	% [86-114]	6010B	02/02/00
CORROSIVITY				
Steel Coupon Index	NA			
INORGANICS				
Biochemical Oxygen Demand	NA			
Chemical Oxygen Demand	102	% [90-111]	410.2	02/01/00
pH	NA			
Total Dissolved Solids	NA			
Organic Carbon	NA			
NUTRIENTS				
Nitrate + Nitrite as N	110	% [89-113]	353.2	02/16/00
Phosphorous Total	114	% [89-113]	365.2	01/31/00

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221506
Sample Name: DUPLICATE OF 221501
Sample Date: 01/21/00
Collected by: TOM TANGEN & SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	827	mg/l	2320B	01/25/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/25/00
Alkalinity Total as CaCO3	678	mg/l	2320B	01/25/00
Chloride as Cl	849	mg/l	325.3	01/26/00
Sulfate as SO4	197	mg/l	375.3	02/10/00
CATIONS				
Calcium as Ca	244	mg/l	6010B	02/15/00
Magnesium as Mg	39	mg/l	6010B	02/15/00
Sodium as Na	378	mg/l	6010B	02/15/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/17/00
INORGANICS				
Biochemical Oxygen Demand	NA			
Chemical Oxygen Demand	929	mg/l	410.1	02/04/00
pH	8.0	S.U.	150.1	01/25/00
Total Dissolved Solids	2930	mg/l	160.1	01/26/00
Organic Carbon	348	mg/l	CALC.	02/04/00
NUTRIENTS				
Nitrate + Nitrite as N	31.0	mg/l	353.2	02/16/00
Phosphorous Total	0.97	mg/l	365.2	01/31/00

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221507
Sample Name: METHOD BLANK
Sample Date: NONE GIVEN
Collected by: LABORATORY
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	<1	mg/l	2320B	01/25/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	01/25/00
Alkalinity Total as CaCO3	<1	mg/l	2320B	01/25/00
Chloride as Cl	<1	mg/l	325.3	01/26/00
Sulfate as SO4	<5	mg/l	375.3	02/10/00
CATIONS				
Calcium as Ca	<1	mg/l	6010B	02/02/00
Magnesium as Mg	<1	mg/l	6010B	02/02/00
Sodium as Na	<1	mg/l	6010B	02/02/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/17/00
INORGANICS				
Biochemical Oxygen Demand	<3.0	mg/l	405.1	01/26/00
Chemical Oxygen Demand	<5	mg/l	410.2	02/01/00
pH	NA			
Total Dissolved Solids	<10	mg/l	160.1	01/26/00
Organic Carbon	NA			
NUTRIENTS				
Nitrate + Nitrite as N	<0.05	mg/l	353.2	02/16/00
Phosphorous Total	<0.01	mg/l	365.2	01/31/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221508
Sample Name: LABORATORY CONTOL SAMPLE
Sample Date: NONE GIVEN
Collected by: LABORATORY
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	NA			
Alkalinity Carbonate as CO3	NA			
Alkalinity Total as CaCO3	110	% [80-120]	2320B	01/25/00
Chloride as Cl	96	% [80-120]	325.3	01/26/00
Sulfate as SO4	100	% [80-120]	375.3	02/10/00
CATIONS				
Calcium as Ca	102	% [80-120]	6010B	02/02/00
Magnesium as Mg	94	% [80-120]	6010B	02/02/00
Sodium as Na	94	% [80-120]	6010B	02/02/00
CORROSIVITY				
Steel Coupon Index	NA			
INORGANICS				
Biochemical Oxygen Demand	80	% [80-120]	405.1	01/26/00
Chemical Oxygen Demand	95	% [80-120]	410.1	02/04/00
pH	NA			
Total Dissolved Solids	100	% [80-120]	160.1	01/26/00
Organic Carbon	NA			
NUTRIENTS				
Nitrate + Nitrite as N	93	% [80-120]	353.2	02/16/00
Phosphorous Total	101	% [80-120]	365.2	01/31/00

Pore Volume-7

NORTHERN
Analytical Laboratories, Inc.

602 South 25th Street
P O Box 30315
Billings, MT 59107
Telephone: (406) 254-7226
Fax: (406) 254-1389

REPORT TO: ATTN: TOM TANGEN
MAXIM TECHNOLOGIES, INC.
P O BOX 4699
HELENA MT 59604

DATE: March 6, 2000
JOB NUMBER: 87-911
SHEET: 1 of 12
INVOICE NO.: 25517235

REPORT OF: Water Analysis - MDT Column Tests – 9911852.100

CASE NARRATIVE:

On February 1, 2000, these water samples (laboratory numbers 221655 through 221661) were received in our laboratory for analysis. Tests were conducted in accordance with EPA/600/4-79-020 *"Methods for Chemical Analysis of Water and Wastes"*; *"Standard Methods for the Examination of Water and Wastewater"*, 18th Edition; SW-846 *"Test Methods for Evaluating Solid Waste"*, 3rd Edition, updates I, II, IIA, IIB, III.

The condition of the samples upon receipt at the laboratory is noted on the attached sample receipt checklist Chain of custody documentation is enclosed.

The test results are shown on the following pages.

A <sign indicates the value reported was the practical quantitation limit for this sample using the method described. Concentrations of analyte, if present, below this were not quantifiable.

Reviewed by _____
Kathleen A. Smit – Laboratory Manager

RECEIVED
MAR 07 2000
MAXIM TECHNOLOGIES
HELENA, MT

Attachments: Chain of Custody
Sample Receipt Checklist

caj

As a mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of our clients and authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved pending our written approval. Test results apply specifically to the samples tested only. The entire report shall not be reproduced, except in full, without the written approval of the laboratory. Samples will be disposed of after testing is completed unless other arrangements are agreed to in writing.

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221655
Sample Name: COLUMN #1; PV-7
Sample Date: 01/28/00
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	357	mg/l	2320B	02/03/00
Alkalinity Carbonate as CO3	20	mg/l	2320B	02/03/00
Alkalinity Total as CaCO3	325	mg/l	2320B	02/03/00
Chloride as Cl	2	mg/l	325.3	02/01/00
Sulfate as SO4	35	mg/l	375.3	02/10/00
CATIONS				
Calcium as Ca	7	mg/l	6010B	02/02/00
Magnesium as Mg	3	mg/l	6010B	02/02/00
Sodium as Na	169	mg/l	6010B	02/02/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/21/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	02/02/00
Chemical Oxygen Demand	33	mg/l	410.2	02/01/00
pH	8.7	S.U.	150.1	02/01/00
Total Dissolved Solids	480	mg/l	160.1	02/04/00
Organic Carbon	12	mg/l	CALC.	02/04/00
NUTRIENTS				
Nitrate + Nitrite as N	<0.10	mg/l	353.2	02/16/00
Phosphorous Total	0.33	mg/l	365.2	02/23/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221656
Sample Name: COLUMN #2; PV-7
Sample Date: 01/28/00
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	578	mg/l	2320B	02/03/00
Alkalinity Carbonate as CO3	146	mg/l	2320B	02/03/00
Alkalinity Total as CaCO3	718	mg/l	2320B	02/03/00
Chloride as Cl	157	mg/kg	325.3	02/01/00
Sulfate as SO4	151	mg/l	375.3	02/10/00
CATIONS				
Calcium as Ca	23	mg/l	6010B	02/15/00
Magnesium as Mg	36	mg/l	6010B	02/15/00
Sodium as Na	542	mg/l	6010B	02/15/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/21/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	02/02/00
Chemical Oxygen Demand	89	mg/l	410.1	02/04/00
pH	9.5	S.U.	150.1	02/01/00
Total Dissolved Solids	2720	mg/l	160.1	02/04/00
Organic Carbon	33	mg/l	CALC.	02/04/00
NUTRIENTS				
Nitrate + Nitrite as N	<0.05	mg/l	353.2	02/16/00
Phosphorous Total	1.7	mg/l	365.2	02/23/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221657
Sample Name: COLUMN #3; PV-7
Sample Date: 01/30/00
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	1370	mg/l	2320B	02/03/00
Alkalinity Carbonate as CO3	179	mg/l	2320B	02/03/00
Alkalinity Total as CaCO3	1420	mg/l	2320B	02/03/00
Chloride as Cl	152	mg/kg	325.3	02/01/00
Sulfate as SO4	42	mg/l	375.3	02/10/00
CATIONS				
Calcium as Ca	4	mg/l	6010B	02/02/00
Magnesium as Mg	<1	mg/l	6010B	02/02/00
Sodium as Na	930	mg/l	6010B	02/01/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/22/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	02/02/00
Chemical Oxygen Demand	81	mg/l	410.1	02/04/00
pH	9.2	S.U.	150.1	02/01/00
Total Dissolved Solids	2060	mg/l	160.1	02/04/00
Organic Carbon	30	mg/l	CALC.	02/04/00
NUTRIENTS				
Nitrate + Nitrite as N	27	mg/l	353.2	02/16/00
Phosphorous Total	3.4	mg/l	365.2	02/23/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221658
Sample Name: COLUMN #4; PV-7
Sample Date: 01/30/00
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	711	mg/l	2320B	02/03/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	02/03/00
Alkalinity Total as CaCO3	583	mg/l	2320B	02/03/00
Chloride as Cl	152	mg/kg	325.3	02/01/00
Sulfate as SO4	91	mg/l	375.3	02/10/00
CATIONS				
Calcium as Ca	163	mg/l	6010B	02/02/00
Magnesium as Mg	26	mg/l	6010B	02/02/00
Sodium as Na	175	mg/l	6010B	02/02/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/22/00
INORGANICS				
Biochemical Oxygen Demand	4	mg/l	405.1	02/02/00
Chemical Oxygen Demand	525	mg/l	410.1	02/04/00
pH	8.3	S.U.	150.1	02/01/00
Total Dissolved Solids	2070	mg/l	160.1	02/04/00
Organic Carbon	197	mg/l	CALC.	02/04/00
NUTRIENTS				
Nitrate + Nitrite as N	220	mg/l	353.2	02/16/00
Phosphorous Total	0.40	mg/l	365.2	02/23/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221659
Sample Name: COLUMN #5; PV-7
Sample Date: 01/30/00
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	271	mg/l	2320B	02/03/00
Alkalinity Carbonate as CO3	6	mg/l	2320B	02/03/00
Alkalinity Total as CaCO3	233	mg/l	2320B	02/03/00
Chloride as Cl	13	mg/l	325.3	02/01/00
Sulfate as SO4	23	mg/l	375.3	02/10/00
CATIONS				
Calcium as Ca	45	mg/l	6010B	02/02/00
Magnesium as Mg	1	mg/l	6010B	02/02/00
Sodium as Na	54	mg/l	6010B	02/02/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/23/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	02/02/00
Chemical Oxygen Demand	57	mg/l	410.1	02/04/00
pH	8.6	S.U.	150.1	02/01/00
Total Dissolved Solids	397	mg/l	160.1	02/04/00
Organic Carbon	21	mg/l	CALC.	02/04/00
NUTRIENTS				
Nitrate + Nitrite as N	1.39	mg/l	353.2	02/16/00
Phosphorous Total	1.3	mg/l	365.1	02/23/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221660
Sample Name: COLUMN #6; PV-7
Sample Date: 01/30/00
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	843	mg/l	2320B	02/03/00
Alkalinity Carbonate as CO3	114	mg/l	2320B	02/03/00
Alkalinity Total as CaCO3	881	mg/l	2320B	02/03/00
Chloride as Cl	130	mg/kg	325.3	02/01/00
Sulfate as SO4	67	mg/l	375.3	02/10/00
CATIONS				
Calcium as Ca	49	mg/l	6010B	02/02/00
Magnesium as Mg	114	mg/l	6010B	02/02/00
Sodium as Na	85	mg/l	6010B	02/02/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/23/00
INORGANICS				
Biochemical Oxygen Demand	<5	mg/l	405.1	02/02/00
Chemical Oxygen Demand	323	mg/l	410.1	02/04/00
pH	8.7	S.U.	150.1	02/01/00
Total Dissolved Solids	1820	mg/l	160.1	02/04/00
Organic Carbon	121	mg/l	CALC.	02/04/00
NUTRIENTS				
Nitrate + Nitrite as N	140	mg/l	353.2	02/16/00
Phosphorous Total	0.78	mg/l	365.1	02/23/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221661
Sample Name: COLUMN #7; PV-7
Sample Date: 01/30/00
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	278	mg/l	2320B	02/03/00
Alkalinity Carbonate as CO3	13	mg/l	2320B	02/03/00
Alkalinity Total as CaCO3	249	mg/l	2320B	02/03/00
Chloride as Cl	12	mg/l	325.3	02/01/00
Sulfate as SO4	10	mg/l	375.3	02/10/00
CATIONS				
Calcium as Ca	6	mg/l	6010B	02/02/00
Magnesium as Mg	26	mg/l	6010B	02/02/00
Sodium as Na	69	mg/l	6010B	02/02/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/24/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	02/02/00
Chemical Oxygen Demand	31	mg/l	410.2	02/01/00
pH	8.7	S.U.	150.1	02/01/00
Total Dissolved Solids	324	mg/l	160.1	02/04/00
Organic Carbon	12	mg/l	CALC.	02/04/00
NUTRIENTS				
Nitrate + Nitrite as N	0.37	mg/l	353.2	02/16/00
Phosphorous Total	0.17	mg/l	365.2	02/23/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221662
Sample Name: METHOD BLANK
Sample Date: NONE GIVEN
Collected by: LABORATORY
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	<1	mg/l	2320B	02/03/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	02/03/00
Alkalinity Total as CaCO3	<1	mg/l	2320B	02/03/00
Chloride as Cl	<1	mg/l	325.3	02/01/00
Sulfate as SO4	<5	mg/l	375.3	02/10/00
CATIONS				
Calcium as Ca	<1	mg/l	6010B	02/02/00
Magnesium as Mg	<1	mg/l	6010B	02/02/00
Sodium as Na	<1	mg/l	6010B	02/02/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/24/00
INORGANICS				
Biochemical Oxygen Demand	<3	mg/l	405.1	02/02/00
Chemical Oxygen Demand	<5	mg/l	410.2	02/01/00
pH	NA			
Total Dissolved Solids	<10	mg/l	160.1	02/04/00
Organic Carbon	NA			
NUTRIENTS				
Nitrate + Nitrite as N	<0.05	mg/l	353.2	02/16/00
Phosphorous Total	<0.01	mg/l	365.2	02/23/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221663
Sample Name: LABORATORY CONTROL SAMPLE
Sample Date: NONE GIVEN
Collected by: LABORATORY
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	NA			
Alkalinity Carbonate as CO3	NA			
Alkalinity Total as CaCO3	110	% [80-120]	2320B	02/03/00
Chloride as Cl	96	% [80-120]	325.3	02/01/00
Sulfate as SO4	100	% [80-120]	375.3	02/10/00
CATIONS				
Calcium as Ca	102	% [80-120]	6010B	02/02/00
Magnesium as Mg	94	% [80-120]	6010B	02/02/00
Sodium as Na	94	% [80-120]	6010B	02/02/00
CORROSIVITY				
Steel Coupon Index	NA			
INORGANICS				
Biochemical Oxygen Demand	85	% [80-120]	405.1	02/02/00
Chemical Oxygen Demand	95	% [80-120]	410.1	02/04/00
pH	NA			
Total Dissolved Solids	99	% [80-120]	160.1	02/04/00
Organic Carbon	NA			
NUTRIENTS				
Nitrate + Nitrite as N	89	% [80-120]	353.2	02/16/00
Phosphorous Total	91	% [80-120]	365.2	02/23/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221664
Sample Name: DUPLICATE OF 221655
Sample Date: 01/30/00
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	357	mg/l	2320B	02/03/00
Alkalinity Carbonate as CO3	0	mg/l	2320B	02/03/00
Alkalinity Total as CaCO3	325	mg/l	2320B	02/03/00
Chloride as Cl	1	mg/l	325.3	02/01/00
Sulfate as SO4	31	mg/l	375.3	02/10/00
CATIONS				
Calcium as Ca	7	mg/l	6010B	02/15/00
Magnesium as Mg	3	mg/l	6010B	02/15/00
Sodium as Na	158	mg/l	6010B	02/15/00
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	02/28/00
INORGANICS				
Biochemical Oxygen Demand	NA			
Chemical Oxygen Demand	33	mg/l	410.2	02/01/00
pH	8.7	S.U.	150.1	02/01/00
Total Dissolved Solids	481	mg/l	160.1	02/04/00
Organic Carbon	12	mg/l	CALC.	02/04/00
NUTRIENTS				
Nitrate + Nitrite as N	0.08	mg/l	353.2	02/16/00
Phosphorous Total	0.34	mg/l	365.2	02/23/00

mmpy – millimeters of corrosion of a steel coupon per year

Client Name: MAXIM - HELENA, MT
Project No.: 87-911
Laboratory No.: 221665
Sample Name: SPIKE OF 221658
Sample Date: 01/30/00
Collected by: SCOTT COLVIN
Time Sampled: NONE GIVEN
Sample Type: WATER

PARAMETER	MEASURED VALUE		METHOD NUMBER	DATE ANALYZED
ANIONS				
Alkalinity Bicarbonate as HCO3	NA			
Alkalinity Carbonate as CO3	NA			
Alkalinity Total as CaCO3	93	% [89-106]	2320B	02/03/00
Chloride as Cl	95	% [89-113]	325.3	02/01/00
Sulfate as SO4	105	% [88-110]	375.3	02/10/00
CATIONS				
Calcium as Ca	102	% [90-110]	6010B	02/02/00
Magnesium as Mg	100	% [88-112]	6010B	02/02/00
Sodium as Na	97	% [86-114]	6010B	02/02/00
CORROSIVITY				
Steel Coupon Index	NA			
INORGANICS				
Biochemical Oxygen Demand	NA			
Chemical Oxygen Demand	98	% [90-111]	410.1	02/04/00
pH	NA			
Total Dissolved Solids	NA			
Organic Carbon	NA			
NUTRIENTS				
Nitrate + Nitrite as N	91	% [89-113]	353.2	02/16/00
Phosphorous Total	116	% [81-119]	365.2	02/23/00

mmpy – millimeters of corrosion of a steel coupon per year

APPENDIX F

LABORATORY ANALYTICAL REPORT
COVERED LEACH TEST STOCKPILE WATER

ORTHERN
alytical Laboratories, Inc.

602 South 25th Street
P O Box 30315
Billings, MT 59107
Telephone: (406) 254-7226
Fax: (406) 254-1389

REPORT TO: ATTN: STAN STERNBERG
MONTANA DEPT OF TRANSPORTATION
P. O. BOX 201001
HELENA MT 59620-1001

DATE: May 11, 2000
JOB NUMBER: 94-912
SHEET: 1 of 2
INVOICE NO.: 30036

REPORT OF: Water Analysis – MDT ASM Research Project – 9911852.100

CASE NARRATIVE:

On March 2, 2000, this water sample (laboratory number 2000030036-1) was received in our laboratory from Mike Ellerd with Maxim Technologies, Inc., for analysis. Tests were conducted in accordance with EPA/600/4-79-020 *"Methods for Chemical Analysis of Water and Wastes"* and SW-846 *"Test Methods for Evaluating Solid Waste"*, 3rd Edition, updates I, II, IIA, IIB, III.

The condition of the sample upon receipt at the laboratory is noted on the attached sample receipt checklist. Chain of custody documentation is enclosed.

The test results of the analysis are shown on the following page.

A <sign indicates the value reported was the practical quantitation limit for this sample using the method described. Concentrations of analyte, if present, below this were not quantifiable.

Reviewed by _____
Kathleen A. Smit – Laboratory Manager

cc: Mike Ellerd
Maxim Technologies, Inc.
P. O. Box 1413
Bozeman, MT 59771

Attachments: Chain of Custody
Sample Receipt Checklist

caj

mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of our clients and authorization for publication of ments, conclusions or extracts from or regarding our reports is reserved pending our written approval. Test results apply specifically to the samples tested only. entire report shall not be reproduced, except in full, without the written approval of the laboratory. Samples will be disposed of after testing is completed unless r arrangements are agreed to in writing.

Northern Analytical Laboratories, Inc.

Client Name: MONTANA STATE, Dept. of Transportation

Project No.: 9911852.100

Project Name: MDT ASM RESEARCH

Sample No.: 2000030036-1 **Description:** COVERED LEACH PILE TANK

Date Received: 03/02/2000

Date Collected: 03/01/2000 **Collected by:** M.G. ELLERD **Matrix:** WATER

Laboratory Test	Measured Value	Test Units	Test Method	Date of Analysis
ANIONS				
Alkalinity Bicarbonate as HCO3	96	mg/l	2320B	03/09/2000
Alkalinity Carbonate as CO3	0	mg/l	2320B	03/09/2000
Alkalinity Total as CaCO3	79	mg/l	2320B	03/09/2000
Chloride as Cl	16,900	mg/l	325.3	03/08/2000
Sulfate as SO4	56	mg/l	375.3	03/16/2000
CATIONS				
Calcium as Ca	3420	mg/l	200.7	03/07/2000
Magnesium as Mg	570	mg/l	200.7	03/07/2000
Sodium as Na	71,300	mg/l	200.7	03/07/2000
CORROSIVITY				
Steel Coupon Index	<1	mmpy	1110	03/21/2000
INORGANICS				
Organic Carbon	1140	mg/l	410.1	03/14/2000
Biochemical Oxygen Demand	>2000	mg/l	405.1	03/03/2000
Total Dissolved Solids	138,000	mg/l	160.1	03/07/2000
pH	7.2	S.U.	150.1	03/02/2000
Chemical Oxygen Demand	3040	mg/l	410.1	03/14/2000
NUTRIENTS				
Nitrate + Nitrite as N	0.43	mg/l	353.2	03/06/2000
Phosphorous Total	0.15	mg/l	365.2	03/14/2000

CHAIN OF CUSTODY RECORD

MAXIM TECHNOLOGIES INC
600 South 25th Street
Billings, Montana 59101
Phone (406) 248-9161 • Fax (406) 248-9282

MDT ASM RESEARCH PROJECT
Project or Site Name

9911852.100
Project Number

M. G. ELLERD
Sampler Name (Printed)

[illegible]
Contact Name

MAXIM
Report to (Film or Agency)

P.O. BOX 1413 BOZEMAN 59771
Address

M. G. ELLERD
Sampler Signature

DATE COLLECTED	TIME COLLECTED	SAMPLE LOCATION OR DESCRIPTION	COMP OR GRAB	SAMPLE MATRIX	NO. OF CONTAINERS	ANALYSIS REQUIRED	NOTES	LAB NUMBER
3/1/00	1205	OVERFLOW PIT TANK	G	W	3 (1500)		SAME ANALYTICAL PARAMETERS AS MDT COLUMN STUDY SAMPLES FROM MAXIM - HELENA.	222340 ~~(Dup) 341~~ C 3/2/00

Relinquished by: M. G. ELLERD — Date 1/3/00 — Time 1510 — Received by:

Relinquished by: GREYHOUND — Date 3/2/00 — Time 1000 — Received by: Steve Smith

Relinquished by: — Date — Time — Received by:

Relinquished by: — Date — Time — Received by:

Remarks:
ONE PRESERVED W/ 6 ml H_2SO_4 — OTHER TWO RAW

NORTHERN
Analytical Laboratories, Inc.

SAMPLE RECEIPT CHECKLIST

Dear Valued Client: This checklist documents the condition of your sample(s) as it (they) arrived at our lab. Please review it and familiarize yourself with its contents. Should you have any questions or comments, please contact us. Thank you for your use of our services.

Client Name: M-Helena

Project: MDT

Laboratory Number(s): 222340-341

Checklist Completed by: MW 3/2/00 (Initials / Date)

Date/Time Received: 3/2/00 1000 (Date / Time)

Received by: SS

Carrier Name: Bud

Sample Type: H2O

	YES	NO
1. Shipping container in good condition?	✓	
2. Custody seals present on shipping container? Condition: Intact ____ Broken ____		✓
3. Chain of custody present?	✓	
4. Chain of custody signed when relinquished and received?	✓	
5. Chain of custody agrees with sample labels?	✓	
6. Custody seals on sample bottles? Condition: Intact ____ Broken ____		✓
7. Samples in proper container/bottle?*	✓	
8. Sample containers intact?*	✓	
9. Sufficient sample volume for indicated test?*	✓	
10. Ice/Frozen Blue Ice present in shipping container? (circle one) container temperature 2.6°C 2. ____ 3. ____ * (if <0 or>10)	✓	
11. All samples rec'd within holding time?*	✓	
12. VOA vials have zero headspace? * (if contains >5mm headspace)	NA	
13. Trip Blank received?	✓	

	YES	NO
14. pH check performed by: MW		
15. Metals bottle(s) pH <2?	NA	
16. Nutrient bottle(s) pH <2?	✓	
17. Cyanide bottle(s) pH >12?	NA	
18. Sulfide bottle(s) pH >9?		
19. TOC bottle(s) pH <2?		
20. Phenolics bottle(s) pH <2?		
21. Oil & grease bottle(s) pH <2? (checked by analyst)		
22. DRO/418.1 bottle(s) pH <2? (checked by analyst)		
23. Volatiles (VOA) pH <2? (VOA pH checked by analyst)		
24. Herbicides (515) pH <2? (checked by analyst)		
25. Semivolatiles (525) pH <2? (checked by analyst)		
26. Client contacted?		
27. Person contacted		
28. Date contacted		

NOTES: **Samples may be affected when not transported at the temperature recommended by the EPA for the test you've selected. Please contact the lab if you have concerns about the temperature of your samples.**

* **Critical item - if marked "NO" contact lab manager.**

COMMENTS: _____